PUBLISHED EVERY SATURDAY BY

THE W. J. JOHNSTON COMPANY, Limited,

167-177 TIMES BUILDING, NEW YORK.

Established 1874. Incorporated 1889.

Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York.

New England Office, Room 28, Hathaway Building, 620 Atlantic Ave., Boston.
Western Office, 465 The Rookery, Chicago.
Philadelphia Office, 927 Chestnut Street.

SUBSCRIPTION, IN ADVANCE, ONE YEAR, $3.

(Including Postage in the U. S., Canada or Mexico.)
IN CLUBS of four or more, $2.50 a year each; with a free extra copy to the getter up of a club of 8. Foreign subscription, $6 a year.

In requesting your address changed, give **old** *as well as new address.*

ESTABLISHED 17 YEARS AGO, THE ELECTRICAL WORLD is the Pioneer Electrical Journal of America and has well maintained its lead. It has the LARGEST CIRCULATION of any electrical periodical in the world, and is the BEST ADVERTISING MEDIUM.

Correspondence, views and opinions on all topics within the province of this journal are cordially invited from any part of the world. We will thank readers to forward to us—**promptly** as they occur—**Items of News,** or information relating to any application of Electricity, also marked copies of their local papers containing anything likely to interest electricians. Anonymous communications cannot be noticed, nor can rejected manuscript be returned, unless accompanied by the necessary postage when received.

Advertising Rates are much lower than those of any other similar publication, circulation and standing considered, and vary according to space, position and number of insertions. Quotations promptly furnished. Situation or Help Wanted advertisements $1 to $2 an insertion, according to length.

Address all communications to

THE W. J. JOHNSTON COMPANY, Ltd.
Times Building, New York,
OR ANY OF THE BRANCH OFFICES.

VOL. XVII. NEW YORK, MARCH 21, 1891. No. 12.

CONTENTS.

EDITORIAL: PAGE.
Paragraphs ... 221

ILLUSTRATED ARTICLES:
Variations of Current in the Primary Conductor of Open Circuit Transformers, by Robert Shand ... 222
An Unique Mining Plant ... 223
The Construction and Care of Electric Railroads: II. General Remarks on Line Construction, etc., by Arthur E. Colgate. 224
The Magnetic Circuit of Transformers: Closed versus Open, by S. Evershed ... 225
Transformer Distribution, by J. Swinburne ... 227
The Inventions of Thomas Davenport, by Franklin L. Pope ... 228
A Waterproof Socket ... 229
Grease Tubes for Loose Pulleys ... 229
Discussion of Mr. O. T. Crosby's Paper on High Speed Electric Railway Work ... 229

MISCELLANEOUS:
Latest Foreign Electrical News ... 222
New Books ... 222
Reminiscences of Thomas Davenport, by Riley Bowers ... 222
Electrical Standards Committee of the Board of Trade ... 222
Phenomena of Alternating Currents of Very High Frequency, by Nikola Tesla ... 223
The National Electric Light Association ... 232
An Electrical Trumpet ... 232
Preparations in Montreal for the Midsummer Convention ... 232
An Accident in New York City ... 232

FINANCIAL INTELLIGENCE: The Electrical Stock Market, 232; New Incorporations, 232; Affairs of the Companies, 233.

SPECIAL CORRESPONDENCE: New York Notes, 233; New England Notes, 233; Western Notes, 233; Philadelphia Notes, 233; English Notes, 233.

ANSWERS TO CORRESPONDENTS ... 234
NEWS OF THE WEEK: The Telephone, 234; The Electric Light, 234 The Electric Railway, 234; Personals, 234; Legal Notes, 234.
INDUSTRIAL AND TRADE NOTES ... 235
BUSINESS NOTICE ... 235
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS ... 236

Electrical Amateurs. IT is difficult to realize, unless one is fortunate enough to have special facilities for observation, how large a number of persons now have an active interest in electrical experimenting and study. Hardly a town but has one or more amateur electricians who take an intelligent interest in every bit of progress that is made, and are constantly striving to secure information on electrical subjects. It is a fortunate state of things, for it will certainly lead to a much more general public comprehension of electricity than now exists. One of the great difficulties that has to be met in introducing the applications of electricity is the oftentimes very dense ignorance by which the efforts are hampered. No amount of foreign missionary work in scientific matters is altogether effective, and it is to the intelligent electrical amateur, the home missionary, as it were, of things electrical, that we must look to diffuse correct ideas regarding practical science. To the amateur, then, we would say, feel your responsibility and use your most earnest endeavors to get for yourself ideas on modern electricity that are correct, even if rudimentary, and study the science faithfully and carefully, both for your own good, and to help the formation of the correct public opinion that can do so much to facilitate the growth of electrical industries.

Open Circuit Transformers. WITHIN the past few months a vigorous discussion has been going on regarding the merits or demerits of the open magnetic circuit type of transformer, best exemplified by the hedgehog form of Mr. Swinburne. Its chief virtue is held to be a high average efficiency, with comparatively small variations from no load to full load. The vices most often attributed to it are bad regulation and needless consumption of current on open circuit. A brief paper by Mr. Robert Shand, in our columns this week, gives the results of some experiments intended to throw light on these often raised objections. It is now quite generally understood that a transformer without any iron whatever in it will not regulate properly. Now it goes quite without saying that one can start with such a transformer and obtain all sorts of results from it, according to the amount and disposition of the iron he chooses to put into the magnetic circuit. A few trials of this sort are reported by Mr. Shand, and the sum and substance of them was that the more nearly the hedgehog form is approached the better regulation and the less waste of current with the secondary circuit open. It is quite clear that the hedgehog form could be developed until it became virtually a closed circuit transformer; in fact, such a construction of the magnetic circuit has been employed by Varley, Ferranti, and Gaulard and Gibbs. To generalize still further, the magnetic qualities of any open circuit transformer can be closely simulated by a closed magnetic circuit of proper dimensions. The principal point that Mr. Shand started to prove was the possibility of fair regulation in the open circuit transformer, a fact somewhat disputed, but evident enough from the experiments tried.

The Magnetic Circuit of Transformers. BEARING on the same subject of which we have just been speaking, is the elaborate paper by Mr. Evershed, the first portion of which is published in the current number. It takes up in a very exhaustive manner the questions sharply touched by Mr. Shand, and proceeds to investigate in detail the efficiencies attainable and attained with the open and closed circuit types of transformer. From what has just been said it should be tolerably evident that the relative efficiency of the two forms cannot be readily determined or computed off hand. It is a proper subject, on the contrary, for most exhaustive experiments, under very rigid conditions. Nothing short of a direct comparison of the various sources of loss in the two, and their respective commercial efficiencies, can give us any final decision on their peculiar merits. It is just such an investigation that Mr. Evershed has undertaken. He begins by going in detail into the operation of several closed circuit transformers, working out as closely as may be the individual sources of loss of energy. Afterward the open circuit type will come in for its share of investigation and description. We shall watch for his results with a great deal of interest. They should be examined, however, very critically by those interested in transformer design, for it is hard to make such a comparison quite fair to both parties concerned. Looking at the question in a very general way, the two sources of loss in any transformer are heating due to ohmic resistance and hysteresis in the iron. The former increases with the square of the current, the latter remains very nearly constant. If now there is very little loss in the copper and a relatively large amount in the iron, as the load falls off the efficiency will also diminish very perceptibly. If, on the other hand, the loss in the iron is relatively small the efficiency will be but slightly affected when running at light load. By changing the relative amounts of copper and iron, it is possible to design a transformer for almost any sort of variation of efficiency with load that may seem desirable, subject, of course, to the conditions imposed by the necessity of a reasonably close regulation. The most economical ratio between the sources of loss is no easy thing to determine, and it is to just such researches as this of Mr. Evershed that we must look for information on this important point.

An Unfortunate Occurrence. THE accident of last week whereby a young man lost his life through lack of care in approaching a damaged arc motor is very much to be regretted, both from its fatal result and from the influence it may possibly exert on the use of electric power. The facts we have stated elsewhere in detail. A large arc motor is installed in a factory with an iron covered floor; there is a ground between armature and core; the superintendent receives a sharp shock and carefully warns the workmen to let the affected machine alone, until at the close of the day's work it can be cut out. One of the men disregards this warning and in attempting to shut off the current touches his head against the projecting flange of the pulley, and is killed. It is an accident of a kind not unfamiliar on lighting circuits, but that could occur only very rarely in operating motors. It is the first accident of the kind that has happened. In nearly every place where motors are installed there would be comparatively little danger of a serious ground. To produce a fatal result it is necessary, first, that the generator in some way be grounded; second, there should be connection between the coils and the frame of the motor, and third, that there should be a good connection between the floor and the ground. Seldom, indeed, would such an unfortunate combination take place, and its occurrence now should not cause the least apprehension among the users of electric motors, even on arc circuits. It should simply serve as another warning that too much care cannot be exercised in using high-tension electricity. The precautions required in employing arc circuits are very simple and very easily fulfilled, and in most cases accidents are the result of gross carelessness on the part of the man injured. With proper care arc motors can be used with entire safety, and while they are undoubtedly more dangerous than low-tension constant potential machines, it not infrequently happens that it is a question between the arc motor and no motor at all. We do not ostracize the arc lamp because it employs a high-tension current, why, then, the arc motor? Other things being equal, the constant potential motor is more convenient than the arc machine, but occasions frequently arise when the latter is desirable. Do not be afraid of the electric motor. The same precautions that are taken with lighting circuits will render the use of motors free from danger, and the sad result of a workman's carelessness should serve to warn rather than to terrify.

An Interesting Discussion. IN our columns this week will be found an admirable paper by Mr. Tesla bearing upon the comments made last week by Prof. Thomson on the subject of alternating currents of high frequency. Apparently Prof. Thomson and Mr. Tesla, wonted as they are to investigate along somewhat different lines, are viewing the phenomena concerned from two totally different directions. Aside from the question of the limit of audition, which is now well known to be far above 10,000 vibrations per second, Sir William Thomson's offhand remark to the contrary notwithstanding, the principal difference seems to be on the usefulness or uselessness of a varying current in arc lighting. Prof. Thomson holds, in spite of the periodic variations in the Thomson-Houston machine, that a variable current is of no special advantage. Mr. Tesla vigorously maintains the position that it is very useful. Now, we may divide the question into two parts, the theoretical and the practical. From a theoretical standpoint Mr. Tesla is undoubtedly correct in saying that self-induction in an arc-light circuit is a very valuable thing, inasmuch as it gives the same inertia, so to speak, without the loss entailed by the resistance that would be necessary to insure stability. An arc light machine of low resistance and low self-induction is undoubtedly sensitive to small variations in the conditions outside, and consequently is difficult to regulate properly. If, as is quite possible by using a fluctuating current, self-induction can be made to take the place of resistance in giving stability to the operation of the machine, self-induction is highly desirable. Resistance wastes much energy, self-induction very little. Nevertheless, Prof. Thomson is unquestionably right in his contention that it is entirely practicable to operate an arc light system without either any more self-induction or resistance than appears necessarily in a high voltage direct current dynamo. As a matter of fact, the largest arc light station in the world is operated by machines that are in no way remarkable for high resistance, and give a current singularly free from fluctuations; both machines and lamps operate with entire success, thanks to a very sensitive regulator. Looking at the thing from a purely practical standpoint, neither high self-induction or high resistance would be necessary if we were furnished with an ideal constant current regulator. As such an one is difficult of attainment, the requisite stability is generally secured, either by considerable resistance or considerable self-induction, or both; self-induction is undoubtedly preferable as a matter of economy. The better the regulator, the less of either is necessary. As regards the operation of clutch lamps by smooth and oscillatory currents, there seems to be a similar misunderstanding between the two eminent electricians concerned. A lamp mechanism having as much inertia in the moving parts as is usual in commercial lamps is not fitted to derive much benefit from the extreme sensitiveness that Mr. Tesla attained by using fluctuating currents with proper apparatus. From the standpoint of the central station manager the difference between the two plans for regulation is purely one of theory, for he can get good results from either. The relative sensitiveness of the two devices —regulation by steady current and regulation by vibrating current—is a point to be determined by experiment. Mr. Tesla has unquestionably attained admirable regulation by the latter device, only by using, however, a clutch specially adapted for the currents employed. It is a question of mechanics rather than electrical theory.

Latest Foreign Electrical News.

(By Cable from our Regular Correspondent.)

London, March 16, 1891.—The government telegraph steamer "Monarch" was caught in a violent snowstorm in mid channel while laying the London-Paris cable, and was obliged to run for shelter. This delayed the work temporarily, but it was finally completed on Saturday evening last, so far as can now be judged with entire success. Conversation can be heard admirably over the line, showing that the calculations for the cable were well made.

The discussion of Mr. Swinburne's paper on "The Electrical Distribution of Power" was concluded on Tuesday. There was a sharp debate on Mr. Swinburne's armature reaction theory, in which Mr. Fleming, Prof. Thompson, Prof. Ayrton, Mr. Kapp, Mr. Mordey and Mr. Trotter took part. Mr. Swinburne's views as to the parallel running of alternators were generally considered to be a mere extension of Hopkinson's original theory. It was thought that the all-day efficiency of the hedgehog transformer was much overrated, although sharp differences of opinion were expressed, especially with regard to the contention that the hysteresis loss decreases as the load increases.

A five-ton electric pinnace for the British government was launched on Tuesday. The boat is fitted with Epstein accumulators.

The city authorities of Bristol have voted £66,000 for electric lighting.

A petition for the extension of the Jablochkoff transformer distribution patent is now pending. What the result will be remains to be seen.

NEW BOOKS.

The Electrican Trades' Directory and Handbook for 1891. London: The London Electrician Printing and Publishing Co. 1891. Pp. 730 plus 119. $2.00.

The present issue of this excellent directory is larger and more complete than in any previous years. It contains an immense amount of matter that cannot fail to prove of value to those who are engaged in electrical industries. The increase in size of the current number is very evident, not less than 100 pages, while it contains 300 pages more than the directory for 1889, which is evidence enough of the favor with which the former editions have been received and speaks well for the success of what is really a most valuable book of reference. One of the useful features of the work is a summary of the leading electrical events of the last year, and an enlarged and complete series of short biographies of well-known electricians, many of them accompanied by portraits. The directory portion proper has received large additions, and cannot fail to be thoroughly useful to the engineer and the manufacturer. A great mass of interesting information concerning foreign electrical matters is made available for the English-speaking electrician in a way that cannot fail to be interesting.

Formulaire Pratique de l'Electricien. By E. Hospitalier. G. Masson, Paris. 1891. Pp. 388.

The current volume is the ninth yearly issue of M. Hospitalier's useful treatise. Previous editions have proved successful, beyond any question, and the fact that the work has been translated into English is proof enough of its practical value to the electrical engineer. It contains an exceedingly diversified and useful mass of general electrical information, supplemented by excellent tables of electrical constants. It shows the tendency that is usual in yearly publications of this sort to retain a large amount of old matter, but continual efforts are made to keep it up to date by the addition of new and important facts. The details of well-known foreign machines are given with a completeness that is admirable, and cannot fail to be convenient to dynamo designers in this country and elsewhere. There are so few collections of practical electrical facts and formulæ that a book like the present one has a wide field of usefulness. It should certainly be in the library of every electrician who is able to read simple scientific French. A similar little treatise in English kept carefully up to date would fill a long-felt want, and it is to be hoped that ere long one will be regularly issued.

Variations of Current in the Primary Conductor of Open Circuit Transformers.

BY ROBERT SHAND.

Despite the years during which the subject has received attention from those interested in electrical developments, few subjects are to-day more discussed or receive greater attention than that of the distribution of electrical energy by means of alternating currents and transformers.

Of late interest has been revived to some extent in transformers of the open magnetic circuit type, a revival which is undoubtedly due in great measure to the work done by Mr. James Swinburne in the development of his special "hedgehog" form of open circuit transformer.

The results of a few experiments made upon an open-circuit transformer, the main object of which was to observe the variations of primary current under different conditions of secondary output, etc., may, therefore, be of general interest and incidentally serve to shed a little light on a statement of Mr. William Stanley, Jr., which appeared in one of his recent contributions on this subject. Mr. Stanley states: "In these transformers (open magnetic circuit) the value of the primary current varies comparatively little with the load derived from the secondary circuit, and when such a transformer is gradually loaded the primary current will remain, roughly speaking, constant, possibly varying 10 to 20 per cent."

This statement is misleading, inasmuch as that, though it may be true when considered in reference to some particular case or cases, it is not so in all. Indeed, it would appear purely a question of design in the construction of open circuit transformers whether it be true or not; yet upon the unqualified assertion above quoted arguments are based calculated to bias the mind of the reader.

The experiments above referred to were made with the object, primarily, of observing the values of the primary inducing current under various conditions of the magnetic circuit, and the changes produced in such values by changes in the secondary output. While a claim for anything approaching rigid accuracy is not made for these observations, yet it is believed they approximate the truth with reasonable closeness.

The transformer on which the observations were made had approximately the same number of turns and volume of copper on primary and secondary conductors. The resistances also were about the same. Though such a construction would hardly be suitable in the case of a commercial transformer, in this case it suited the means at hand for making the measurements.

The transformer coils formed a cylinder having an opening through its centre two inches in diameter, into which the core was introduced, the outside diameter of the coils being six inches, the length seven inches and the weight about 30 pounds.

For observing the primary potential a Cardew voltmeter was employed, for power measurements a wattmeter having a large additional resistance in series with

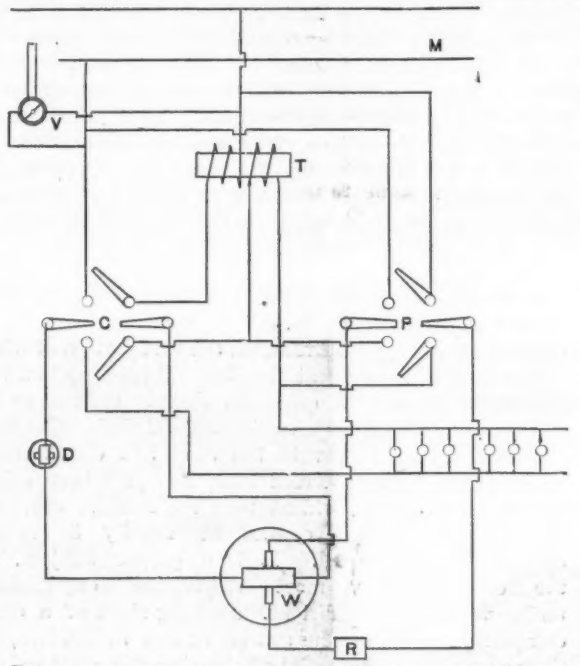


Diagram of Connections for Transformer Tests.

the suspended pressure coil, and for current measurements a Siemens electro-dynamometer. These instruments were disposed as shown in the figure, the commutating or switching devices C and P rendering it easy to connect them in either circuit, and to transfer them rapidly from one to the other. The primary potential varied from 100 volts in some cases to 104 in others. It was, however, kept fairly constant during each set of observations.

The drop given is, in each case, that observed when the secondary output was approximately 1,000 watts. Results given in table I. were obtained from the copper coils alone, no iron whatever being employed.

In table II. it will be observed that the energy taken up by the transformer when cold is very nearly two per cent. greater than that taken up after it had been run for some time and thus become heated. This effect was probably due to a decrease in the volume of parasitic currents in the core when the latter became heated.

TABLE I.

(No iron used; drop = 3.4 volts.)

Primary potential.	Primary current.	Primary watts.	Secondary current.	Secondary watts.	Efficiency, per cent.
100	52	657	.....	.....	....
100	53	1,630	11.35	960	.59
100	54	.....	19.	1,564	.68 (?)

When secondary load was 1,564 watts the primary power was beyond the capacity of wattmeter.

TABLE II.

(Small iron wire core same length as coils; induction per centimetre of core, 23,000; drop = 3.5 volts.)

Primary potential.	Primary current.	Primary watts.	Secondary current.	Secondary watts.	Efficiency, per cent.
104	16.5	110 (cold) / 108 (hot)	....	....	....
104	16.7	339	2.2	220	.65
104	17.2	531	4.14	410	.77
104	19.4	1,115	10.1	972	.87

TABLE III.

(Core of iron wire 7 inches long; induction, 14,000; drop = 3.5 volts.)

Primary potential.	Primary current.	Primary watts.	Secondary current.	Secondary watts.	Efficiency, per cent.
104	14	86	....	....	....
104	14.4	360	2.1	210	.70
104	14.7	504	4.15	410	.81
104	19.1	1,334	12.2	1,185	.88

TABLE IV.

(Iron wire core 13 inches long, projecting at each end three inches beyond the copper coils; induction, 6,300; drop = 3.4 volts.)

Primary potential.	Primary current.	Primary watts.	Secondary current.	Secondary watts.	Efficiency, per cent.
100	7.3	45	....	....	....
100	8	330	2.9	280	.848
100	13.8	1,147	11.2	1,057	.92
100	19.1	1,699	17	1,558	.918

TABLE V.

(Same iron wire core used as in table IV. The ends, however, instead of projecting straight out from the centre of the coil, were bent over flat and arranged radially over the ends of the copper coils. Induction, 6,300; drop = 3.5 volts.)

Primary potential.	Primary current.	Primary watts.	Secondary current.	Secondary watts.	Efficiency, per cent.
100	3.27	43	....	....	....
100	3.9	142	....	97	.68
100	4.4	268	2.24	221	.825
100	6.7	574	5.3	518	.902
100	11.2	1,078	10.3	994	.922
100	16.3	1,550	15.3	1,419	.915

When the core ends instead of being flattened down on the ends of copper coils were bristled up, and made to project out divergingly, the magnetizing current fell to 3.1 ampères. The watts taken up, however (as indicated by wattmeter), remained practically the same.

The iron wire used in the construction of the cores was of poor quality, and was not annealed previous to use, consequently the energy taken up by the cores was without doubt excessive.

The quantity C^2R with the secondary circuit open was in table V. about two watts. If this quantity be accepted as representing the energy consumed over copper resistance, then the consumption of energy by the core comes out about 8,900 ergs per cubic centimetre per cycle.

At induction taken in table V., and with iron of the quality employed by Ewing in making his determinations, the energy taken up by hysteresis ought to be about 3,500 ergs per cubic centimetre per cycle. Consequently, if the consumption of energy be calculated on the basis of copper resistance and Prof. Ewing's curves, it would come out at about 18 watts, and if a quantity equal to one-third of this be allowed for parasitic currents in the core, etc., the total power with open secondary would still only be about 24 watts. Such a power consumption under the condition named would be quite moderate, even in the case of a transformer having so small an output as 1,000 watts.

Again, referring to Mr. Stanley's statement, it may be stated that on theoretical grounds alone it is difficult to understand how he could expect his statement to be substantiated in practice. The results shown in the test tables certainly do not do so. It would, therefore, appear that the objections which he raises to the employment of transformers of the open-circuit type are in reality non-existent as such. So far is it indeed from being the fact that the primary current will not vary more than 10 or 20 per cent. from light to heavy load on the secondary, table V. shows it to vary nearly 500 per cent.

Reminiscences of Thomas Davenport.

BY RILEY BOWERS.

Mr. Thomas Davenport, after returning from England with his electrical railroad, began running a woolen mill in Middlebury, sixteen miles from Brandon, Vt. The mills were known as Davenport & Turner's. Mr. Turner died about the year 1840, and when I left Middlebury in 1848 Mr. Davenport was running the mill by himself. My father had a machine shop adjoining the mill, and it was torn down to make room for a dry-house for the mill. I remember that my father made the wheels for the truck of the machine that Mr. Davenport took to England with him. I also remember that during the absence of my father in the mill to make some repairs it occurred to me that I could make some of the wheels. So I got up on a carpenter's saw-horse and put the wheel in the chuck and set it running. I got the chuck drill—the same that is used now in machine shops—and attempted to run it through the wheel. It happened to be one with a blowhole in the core, and I caught the drill in the blowhole and broke the drill. As a result I received a good spanking and was sent home.

My father told his family in my presence that when Mr. Davenport arrived in New York he was offered $250,000. He would not take it, but took his model to England and set it running. Michael Faraday was well pleased with it, but after it had been running some time it occurred to Faraday to try its power. He took a broom that was in the room, put it against the fly-wheel, and stopped the motor. After that Mr. Faraday refused to invest, or recommend it to others. So Mr. Davenport had to bear all the expense and received nothing for his trouble.

Electrical Standards Committee of the Board of Trade.*

The following draft of resolutions, with others dealing with the practical measurement of power, whether developed by direct or alternating currents, will be submitted to the Electrical Standards Committee for discussion at its next meeting:

1. That it is desirable that new denominations of standards for the measurement of electricity should be made and approved by Her Majesty in Council as Board of Trade Standards.

2. That the magnitudes of these standards should be determined with reference to the centimetre as unit of length, the gramme as unit of mass, and the second as unit of time, and that by the terms centimetre and gramme are meant the standards of those denominations deposited with the Board of Trade.

3. That the standard of electrical resistance should be denominated the ohm, and should have the value 1,000,000,000 in terms of the centimetre and second.

*From *The Electrician*, London.

4. That the resistance offered to an unvarying electric current by a column of mercury of a constant cross sectional area of one square millimetre, and of a length of 106.3 centimetres at the temperature of melting ice, may be adopted as one ohm.

5. That the value of the standard of resistance constructed by a committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as .9866 of the ohm.

6. That a material standard constructed in solid metal, and verified by comparison with the British Association unit should be adopted as the Board of Trade standard ohm.

7. That for the purpose of replacing the standard, if lost, destroyed or damaged, and for ordinary use, one or more copies should be constructed, which should be periodically compared with the standard ohm and with the British Association unit.

8. That the standard of electrical current should be denominated the ampère, and should have the value one-tenth (0.1) in terms of the centimetre, gramme and second.

9. That an unvarying current which, when passed through a solution of nitrate of silver and water containing from 15 to 20 parts by weight of nitrate of silver in 100 parts of water, deposits silver at the rate of 0.001118 of a gramme per second, may be taken as a current of one ampère.

10. An alternating current of one ampère shall mean a current such that the square root of the time average of the square of its strength at each instant, in ampères, is unity.

11. That an instrument constructed on the principle of the balance, in which by the proper disposition of the conductors forces of attraction and repulsion are produced which depend upon the amount of current passing, and are balanced by a known weight, should be adopted as the Board of Trade standard for the measurement of one ampère, whether the current be unvarying or alternating.

12. That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampère.

13. That the electrical pressure at a temperature of 62 degrees F. between the poles or electrodes of the voltaic cell, known as Clark's cell, constructed and used in accordance with the specification attached to these proceedings, may be taken as not differing by more than ..... parts in one thousand from a pressure of..... volts.

An Unique Mining Plant.

Far up among the mountains of Southwestern Colorado lies the little mining town of Telluride. It is one of the oldest mining camps in Colorado, but in these days of mining on a large scale it has not come into prominence until very recently, for the gold lies high up among the hills, thousands of feet above the San Miguel Valley. The ore, although abundant, is not of high grade, and the cost of mining and milling has heretofore been so great as to almost prohibit successful operation. The Gold King Milling and Mining Company, that owns this group of mines, has been in operation for several years, but never with profit until recently. About a year ago Mr. L. L. Nunn, of Telluride, took the general management of the mines, and has made them pay by careful business policy, and the more important fact that he realizes that the only way of operating a low-grade mine is to do it on a very large scale. Until this spring the Gold King Company used a 40 stamp amalgam mill, which with several large ore crushers was operated by a 60 h. p. engine. But during the few years of its operations the needs of the mill, which is above the timber line, had so greatly reduced the available fuel that formerly grew in abundance a few hundred feet below, that the question of motive power had grown to be a very serious one. On consideration it seemed absolutely necessary that some system of electrical transmission of power should be employed, so that one of the great water powers in the immediate neighborhood could operate the mills.

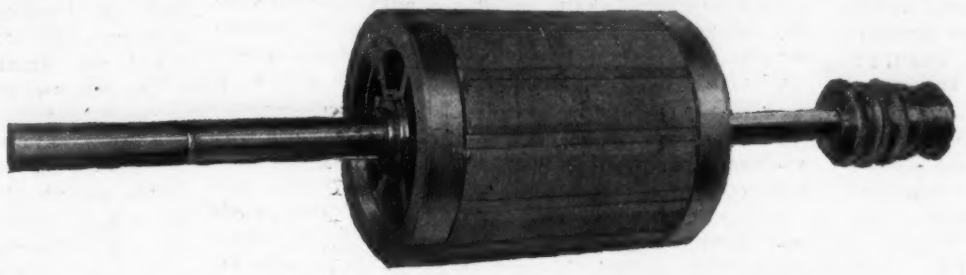


FIG. 2.—ARMATURE OF WESTINGHOUSE MOTOR AND GENERATOR.

The Gold King Mill is at an elevation of 11,000 feet above the sea, and 3,000 feet above the San Miguel Valley. The south fork of the San Miguel River in its descent from Ophir, a mining camp near Telluride, falls 500 feet in a distance of less than a mile. The river is fed almost entirely from springs in the Ophir basin, and even at the season of lowest supply can furnish about 2,000 h. p. Here was available power enough to operate every mine in the vicinity, and on taking up the question of electricity the scene was looked over by various engineers, and finally the Gold King Company closed a contract with the Westinghouse Electric & Manufacturing Company to supply the necessary machinery. A dam has been erected at what is an almost perfect natural site above the beginning of the rapid descent of the stream, and from the headgate the water is conducted through an iron pipe 4,000 feet long, at the beginning some 20 inches in diameter, and then gradually decreasing to 12, along the valley to the power station. Here the stream is divided, and the water is delivered to two six-foot Pelton water wheels in the generating station itself. The ultimate capacity of 800 h.p. in the generators is provided for, although at present only a single 100 h. p. machine will be installed. The motor station is two and a half miles from the generators. It was determined to employ in this large plant synchronous alternating motors, for the reason that the potentials required would be higher than are usually reached in practice by direct current motors, and the method of governing the motors rendered it possible, conveniently, to operate the motors at all sorts of potentials from the same circuit if it should be found desirable. The generator employed is of the same type as the Westinghouse self-exciting incandescent machine with toothed armature. Motor and generator are alike, except in some minor details, and the machines are well shown in Fig. 1. The armature (Fig. 2) is seen to possess the ordinary Westinghouse arrangement of teeth, and has otherwise no striking peculiarities. It was determined to use an electromotive force of 3,000 volts, and the machines are accordingly wound for this potential. The conducting circuit is a No. 3 B. & S. gauge, bare copper wire, erected on stout poles at a sufficient distance above the ground to prevent anything but the remotest possibility of accident. The loss in transmission is barely 5 per cent. The motor being of the synchronizing type, the question of starting it very naturally arises. This has always been the most serious difficulty with alternating currents for the transmission of power. In this case the solution was easy, for while used for the purposes designed the motor does not have to be started at all frequently. Once in step with the generator it may run for many hours without being stopped for any reason whatever. The starting device employed is a two-wire alternating motor of the Tesla form of construction of about 10 h. p. capacity: this machine is shown in Fig. 3. It is used simply and solely for bringing the large motor up to synchronism, when it is cut out until again required. The large motor is self-exciting, and takes care of itself easily enough after it is once brought up to speed. This Telluride plant promises to be, when it shall finally be put into operation a few weeks hence, one of the most interesting mining plants in the world from the nature of its location, which made electrical power a necessity, and especially from the daring way in which the difficulty of using very high potential has been met by employing a synchronizing motor. It is altogether probable that other mines in the vicinity will shortly receive a similar equipment, as the region is one where fuel is none too easily obtained, and water power can be had almost for the asking. The plant is now rapidly nearing completion, and ere long we may hope to chronicle the starting of an installation that is unique in the electrical transmission of power among motor plants, and that has every reason to meet with most gratifying success.

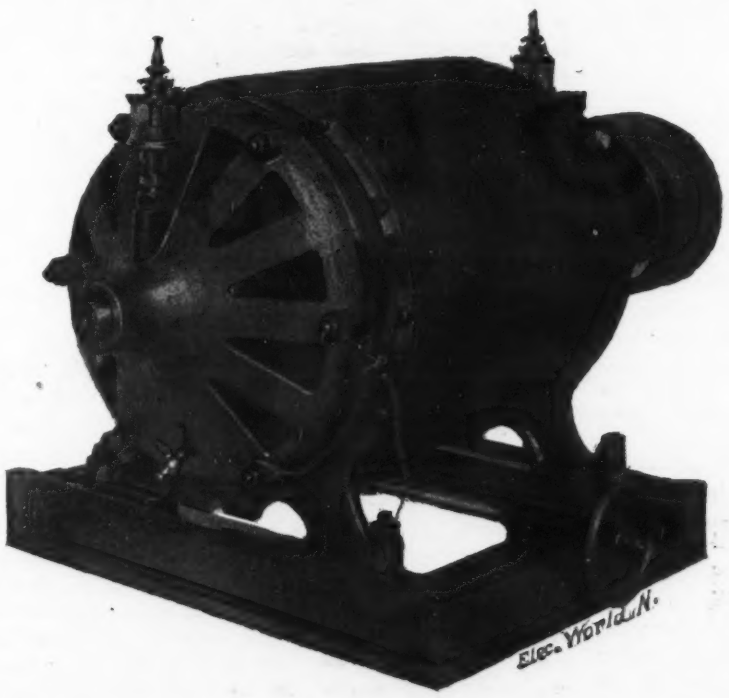


FIG. 3.—TESLA MOTOR USED IN THE TELLURIDE PLANT.

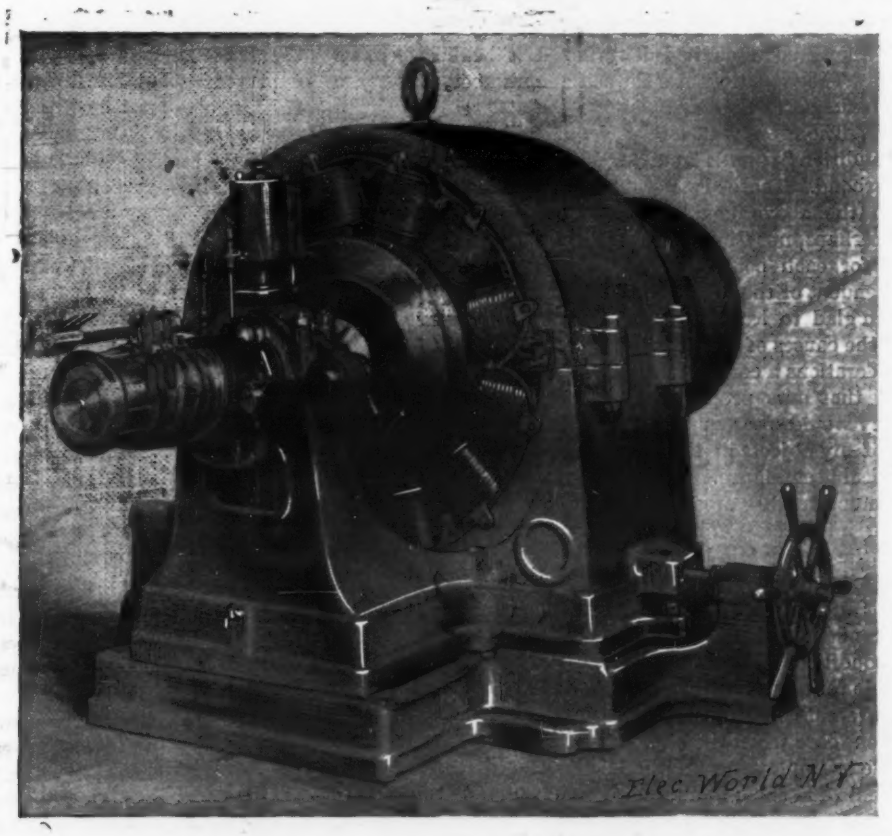


FIG. 1.—MOTOR AND GENERATOR OF THE TELLURIDE MINING PLANT.

Phenomena of Alternating Currents of Very High Frequency.

BY NIKOLA TESLA.

In the issue of THE ELECTRICAL WORLD of March 14 I find a note of Prof. Elihu Thomson relating to some of my experiments with alternating currents of very high frequency which have been described in THE ELECTRICAL WORLD of Feb. 21, 1891.

Prof. Thomson calls attention to the interesting fact that he has performed some experiments in the same line. I was not quite unprepared to hear this, as a letter from him appeared in *The Electrician* (London) a few months ago in which he mentioned a small alternate current machine which was capable of giving, I believe, 5,000 alternations per second, from which letter it likewise appears that his investigations on that subject are of a more recent date.

Prof. Thomson describes an experiment with a bulb inclosing a carbon filament which was brought to incandescence by the bombardment of the molecules of the residual gas when the bulb was immersed in water rendered slightly conducting by salt dissolved therein (?) and a potential of 1,000 volts, alternating 5,000 times a second, applied to the carbon strip. Similar experiments have, of course, been performed by many experimenters, the only distinctive feature in Prof. Thomson's experiment being the comparatively high rate of alternation. These experiments can also

be performed with a steady difference of potential between the water and the carbon strip, in which case, of course, conduction through the glass takes place, the difference of potential required being in proportion to the thickness of the glass. With 5,000 alternations per second conduction still takes place, but the condenser effect is preponderating. It goes, of course, without saying that the heating of the glass in such a case is principally due to the bombardment of the molecules, partly also to leakage or conduction, but it is an undeniable fact that the glass may also be heated merely by the molecular displacement. The interesting feature in my experiment was that a lamp would light up when brought near to an induction coil, and that it could be held in the hand and the filament brought to incandescence.

Experiments of the kind described I have followed up for a long time with some practical objects in view. In connection with the experiment described by Prof. Thomson, it may be of interest to mention a very pretty phenomenon which may be observed with an incandescent lamp. If a lamp be immersed in water as far as practicable, and the filament and the vessel connected to the terminals of an induction coil operated from a machine such as I have used in my experiments, one may see the dull red filament surrounded by a very luminous globe, around which there is a less luminous space. The effect is probably due to reflection, as the globe is sharply defined, but may also be due to a "dark space;" at any rate it is so pretty that it must be seen to be appreciated.

Prof. Thomson has misunderstood my statement about the limit of audition. I was perfectly well aware of the fact that opinions widely differ on this point. Nor was I surprised to find that arcs of about 10,000 impulses per second emit a sound. My statement, "the curious is," etc., was only made in deference to an opinion expressed by Sir William Thomson. There was absolutely no stress laid on the precise number. The popular belief was that something like 10,000 to 20,000 per second, or 20,000 to 40,000 at the utmost, was the limit. For my argument this was immaterial; I contended that sounds of an incomparably greater number, that is, many times even the highest number, could be heard if they could be produced with sufficient power. My statement was only speculative, but I have devised means which I think may allow me to learn something definite on this point. I have not the least doubt that it is simply a question of power. A very short arc may be silent with 10,000 impulses per second, but just as soon as it is lengthened it begins to emit a sound. The vibrations are the same in number, but more powerful.

Prof. Thomson states that I am taking as the limit of "audition" sounds from 5,000 to 10,000 complete waves per second. There is nothing in my statements from which the above could be inferred, but Prof. Thomson has, perhaps, not thought that there are two sound vibrations for each complete current wave, the former being independent of the direction of the current.

I am glad to learn that Prof. Thomson agrees with me as to the causes of the persistence of the arc. Theoretical considerations a considerable time since had led me to the belief that arcs produced by currents of such high frequency would possess this and other desirable features. One of my objects in this direction has been to produce a practicable small arc. With these currents for many reasons much smaller arcs are practicable.

The interpretation by Prof. Thomson of my statements about the arc system leads me now—he will pardon me for saying it—to believe that what is most essential to the success of an arc system is good management. Nevertheless I feel confident of the correctness of the views expressed. The conditions in practice are so manifold that it is impossible for any type of machine to prove best under all the different conditions.

In one case when the circuit is many miles long, it is desirable to employ the most efficient machine with the least internal resistance; in another case such a machine would not be the best to employ. It will certainly be admitted that a machine of any type must have a greater resistance if intended to operate arc lights than if it is designed to supply incandescent lamps in series. When arc lights are operated and the resistance is small, the lamps are unsteady, unless a type of lamp is employed in which the carbons are separated by a mechanism which has no further influence upon the feed, the feeding being effected by an independent mechanism; but even in this case the resistance must be considerably greater to allow a quiet working of the lamps. Now, if the machine be such as to yield a steady current there is no way of attaining the desired result except by putting the required resistance somewhere either inside or outside of the machine. The latter is hardly practicable, for the customer may stand a hot machine, but he looks with suspicion upon a hot resistance box. A good automatic regulator, of course, improves the machine and permits the reduction of the internal resistance to some extent, but not as far as would be desirable. Now since resistance is loss, we can advantageously replace resistance in the machine by any equivalent impedance. But to produce a great impedance with small ohmic resistance it is necessary to have self-induction and variation of current, and the greater the self-induction and the rate of change of the current, the greater the impedance may be made, while the ohmic resistance may be very small. It must also be remarked that the impedance of the circuit external to the machine is likewise increased. As regards the increase in ohmic resistance in consequence of the variation of the current, this is, in the commercial machines now in use, very small. Clearly then a great advantage is gained by providing self-induction in the machine circuit and undulating the current, for it is possible to replace a machine which has a resistance of, say, 16 ohms by one which has no more than 2 or 3 ohms, and the lights will work even steadier. It seems to me, therefore, that my saying that self-induction is essential to the commercial success of an arc system is justified. What is still more important, such a machine will cost considerably less. But to realize fully the benefits it is preferable to employ an alternate current machine, as in this case a greater rate of change in the current is obtainable. Just what the ratio of resistance to impedance is in the Brush and Thomson machines is nowhere stated, but I think that it is smaller in the Brush machine, judging from its construction.

As regards the better working of clutch lamps with undulating currents, there is, according to my experience, not the least doubt about it. I have proved it on a variety of lamps to the complete satisfaction not only of myself but of many others. To see the improvement in the feed due to the jar of the clutch at its best it is desirable to employ a lamp in which an independent clutch mechanism effects the feed, and the release of the rod is independent of the up and down movement. In such a lamp the clutch has a small inertia and is very sensitive to vibrations, whereas if the feed is affected by the up and down movement of the lever carrying the rod, the inertia of the system is so great that it is not affected as much by vibrations, especially if, as in many cases, a dash-pot is employed. During the year 1885 I perfected such a lamp which was calculated to be operated with undulating currents. With about 1,500 to 1,800 current impulses per minute, the feed of this lamp is such that absolutely no movement of the rod can be observed, even if the arc be magnified fifty-fold by means of a lens, whereas if a steady current is employed the lamp feeds by small steps. I have, however, demonstrated this feature on other types of lamps, among them being a derived circuit lamp such as Prof. Thomson refers to I conceived the idea of such a lamp early in 1884, and when my first company was started this was the first lamp I perfected. It was not until the lamp was ready for manufacture that, on receiving copies of application from the Patent Office, I learned for the first time, not having had any knowledge of the state of the art in America, that Prof. Thomson had anticipated me and had obtained many patents on this principle, which, of course, greatly disappointed and embarrassed me at that time. I observed the improvement of the feed with undulating currents on that lamp, but I recognized the advantage of providing a light and independent clutch unhampered in its movements. Circumstances did not allow me to carry out at that time some designs of machines I had in mind, and with the existing machines the lamp has worked at a great disadvantage. I cannot agree with Prof. Thomson that small vibrations would benefit a clockwork lamp as much as a clutch lamp; in fact, I think that they do not at all benefit a clockwork lamp. It would be interesting to learn the opinion of Mr. Charles F. Brush on these points.

Prof. Thomson states that he has run with perfect success clutch lamps "in circuit with coils of such large self-induction that any but very slight fluctuations were wiped out." Surely Prof. Thomson does not mean to say that self-induction wiped out the periodical fluctuation of the current. For this just the opposite quality, namely, capacity, is required. The self-induction of the coils in this case simply increased the impedance and variations occurring at large time intervals, which take place when the resistance in circuit with the lamps is too small, or even with larger resistance in circuit when the dash-pots either in the lamps or elsewhere are too loose.

Prof. Thomson further states that, in a lamp in which the feed mechanism is under the control of the derived circuit magnet only, the fluctuations pass through the arc without affecting the magnet to a perceptible degree. It is true that the variations of the resistance of the arc in consequence of the variations in the current strength are such as to dampen the fluctuation. Nevertheless, the periodical fluctuations are transmitted through the derived circuit, as one may convince himself easily by holding a thin plate of iron against the magnet.

In regard to the physiological effects of the currents, I may state that upon reading the memorable lecture of Sir William Thomson, in which he advanced his views on the propagation of the alternate current through conductors, it instantly occurred to me that currents of high frequencies would be less injurious. I have been looking for a proof that the mode of distribution through the body is the cause of the smaller physiological effects. At times I have thought that I was able to locate the pain in the outer portions of the body, but it is very uncertain. It is most certain, however, that the feeling with currents of very high frequencies is somewhat different from that with low frequencies. I have also noted the enormous importance of one being prepared for the shock or not. If one is prepared the effect upon the nerves is not nearly as great as when unprepared. With alternations as high as 10,000 per second and upward, one feels but little pain in the central portion of the body. A remarkable feature of such currents of high tension is that one receives a burn instantly he touches the wire, but beyond that the pain is hardly noticeable.

But since the potential difference across the body by a given current through it is very small, the effects cannot be very well ascribed to the surface distribution of the current, and the excessively low resistance of the body to such rapidly varying currents speaks rather for a condenser action.

In regard to the suggestion of Dr. Tatum, which Prof. Thomson mentions in another article in the same issue of The Electrical World, I would state that I have constructed machines with as many as 480 poles, from which it is possible to obtain about 30,000 alternations per second, and perhaps more. I have also designed types of machines in which the field would revolve in an opposite direction to the armature, by which means it would be possible to obtain from a similar machine 60,000 alternations per second or more.

I value highly the appreciation by Prof. Thomson of my work, but I must confess that in his conclusion he makes a most astounding statement as to the motives of his critical remarks. I have never for a moment thought that his remarks would be dictated by anything but friendly motives. Often we are forced in daily life to represent opposing interests or opinions, but surely in the higher aims the feelings of friendship and mutual consideration should not be affected by such things as these.

The Construction and Care of Electric Railroads: II.—General Remarks on Line Construction, etc.

BY ARTHUR E. COLGATE.

This article consists largely of some general remarks and formulæ relative to the amount of power lost in overcoming the resistance of the trolley and feed wires, and the locating of the poles, together with various other formulæ which may prove useful to the constructor. The power which may be said to be lost in this manner is in reality spent in heating the conductors, and is easily calculated by the formula,

$$\frac{C^2 R}{746} = \text{the horse power lost.}$$

The resistance of a copper wire is very nearly what is expressed by the formula 32.37 times its length in yards, divided by the square of its diameter in thousandths of an inch; and for other metals the resistance may be found in the same manner, the constant being changed according to the relative conductivity compared to that of copper. For example, if the conductivity is half that of copper, the constant should be multiplied by two. The formula is based on the resistance of a copper wire one yard long and of one circular mil sectional area, and as the conductivity of silicon bronze and most other trolley wires is about from 25 to 40 per cent. higher than that of copper, either the constant or the result should be multiplied by 1 plus the per cent. increase of resistance.

Where feed wires are run in connection with the trolley lines, and are cross connected with them at short distances, the joint resistance may be considered as that of one conductor, whose resistance is equal to the product of the several resistances divided by their sum, and the loss of power calculated in the same manner as it would be in one wire. The loss permissible on a line depends greatly on the grade and cost of power. In most cases, where coal is reasonable, it is about 25 per cent. of the total amount developed by the generators, and on grades it should be much less, the current being supplied at these points by a separate feed wire, and a circuit-breaker being put in both trolley lines at the top and bottom of the hill, if it is a short one; and if it is sufficiently long to warrant it, the circuit should be again broken in the centre of the grade. The object of this is to protect the rest of the system should any car motor burn out or the line become grounded through defective car wiring, the insulation of which would be liable to give way and ground the line when subjected to heavy service on grades.

The weight of copper wire is about equal to the square of its diameter in thousandths of an inch multiplied by the constant (which is .016), and its tensile strength 11 times its radius in thousandths of an inch squared multiplied by the strength of a square inch of the material, which, in the case of copper, is 61,200 pounds, and in the case of iron 103,000 pounds. The strength of cable wire is about 10 per cent. more than that of the various strands of which it is composed, and the strength of rope is expressed by the circumference squared multiplied by the constant, which is for white rope 1,140 and for manila 810, the strength of tarred ropes being about 10 per cent. less. The weight of round iron poles is 2.65 times the mean outside diameter squared, divided by the square of the internal diameter multiplied by the length of the pole.

Where the use of untried apparatus is contemplated, tests as to the relative strength and durabilty under strain should be made by means of a testing machine. Imagine a case in which a log of wood about ten feet long and eight inches in diameter is held in an upright position by suitable means. Projecting pieces of wood, are bolted to the log by inch bolts or lag

screws, there being two chains of half-inch iron links, kept from sliding together by means of projecting bolts. A small Fairbanks dynamometer is used, but, if not procurable, may be replaced by a steel-yard. There are two clamps, one of which is attached to the dynamometer and the other to the turnbuckle by means of a swivel. The piece of apparatus to be tested, having had short pieces of suitable trolley wire attached to it in the regular manner, is held by means of these and the clamps, and the strain applied by the turnbuckle, the amount of which should be read on the dial of the dynamometer. Should a steelyard be used, it will be much more convenient if a small spring balance is substituted for the weight or counterbalance.

If it is thought necessary or desirable to test any of the various makes of poles, it may be done as is shown in Fig. 1, in which strong pieces of wood are firmly set in the ground, and a stout piece of hard wood is placed behind the pole to distribute the strain evenly along that part which is afterward set in the ground. The strain is applied and read in the same manner as in the previous case, by means of the dynamometer and turnbuckle. In applying this test to side and pull-off poles, the rope or chain by

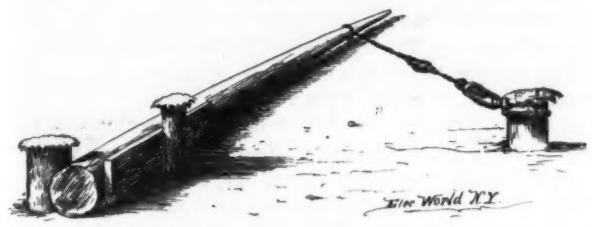


FIG. 1.—TESTING A POLE.

which the strain is brought to bear should be attached to the insulated cap at the top, which is usually the weakest part of the pole. This has proved so weak in many instances that constructors are discarding it, and are attaching the span and pull-off wires to circuit breakers, which are attached to the pole a few inches from the top by a short pendant and turnbuckle, or by means of an insulated turnbuckle. These methods, while not presenting so symmetrical an appearance, have a most decided advantage of superior strength and durability.

In centre construction a pole should be set as near each end of the curve as possible without involving danger of being struck by the overhanging ends of the cars. The precise point for the location may be found as is shown in Fig. 2. A line with the distances corresponding to the length of the wheel base and distances from the rear axle to the front dashboard of the car marked on it is held between three men. The men who represent the wheel base, 1 and 2, stand on the inside rail, the other stand-

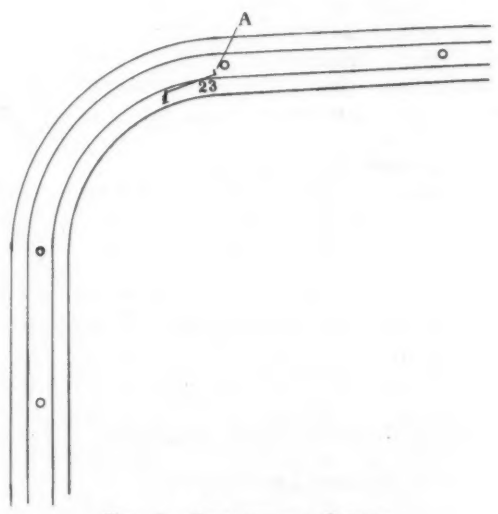


FIG. 2.—LOCATING A CURVE.

ing in line with them at the point representing the forward dasher. A short stick is held by him at right angles to the line. The curve is followed in this manner, and the location should be fixed at a point where the stick clears a line drawn parallel to the rails between the tracks by a little more than half the diameter of the pole.

Fig. 3 shows the correct location of a pull-off pole, which is found by an equilateral triangle *B*, having for its base a line drawn between the last two poles, located at the ends of the curve *A A*, the apex of which is the pull-off pole *C*. If it is not convenient to set it here, it may be moved farther back, or a short distance to the right or left, as circumstances may require, or the pull-offs may be brought together at this point and made up into an iron ring with a pendant running to the pole, or two poles may be placed at the points *E* and *F*, and the ring secured by pendants running from them. In the case of side pole and span wire, construction poles should be placed at the points represented and a span wire run between them, as shown by the dotted lines, the object being to support the curve and keep slack from running back should the pull-off pole bend to any extent or should the wire part. The ears by which the trolley is fastened to these spans should in all cases be soldered very firmly with a solder composed of equal parts of tin and lead soldering, salts being used as a flux.

Poles are often located by means of pins driven into a ard onto which a sketch of the curve and line has been pasted, the line being in this case represented by a thread which is pulled out over the track in the same manner as the trolley line should be. In the diagram, Fig. 4, *A* is an elastic band fastened to the board by a nail *B*, *C C* being the pins which represent the poles at each end of the curve, around which the thread is run and anchored to the pin *E*. *F F F* are pins driven into the board on the curve line at a distance of eight or ten feet apart, on the scale to which the sketch is drawn, which serve as a guide to the length

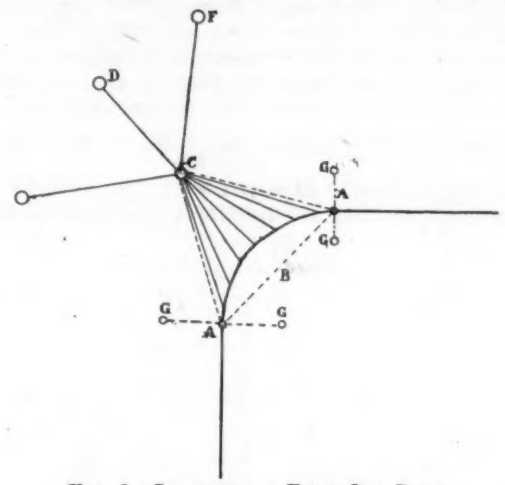


FIG. 3.—LOCATING A PULL-OFF POLE.

of the pull-offs, and which are attached to the pull-off pole *H*, on the curb line. After the line is pulled out against the pins they are removed, and if the thread follows the curve the location of the poles is correct.

When there is a switch in the line, where it branches in the shape of a Y, the curves may be pulled from each other as is shown in Fig. 5, in which *A* is the switch, *B* is a pull-off pole, which is located in line with the switch *A*, and *C C C* are the last poles on the straight line. The switch *A* should be situated about four feet beyond the switch

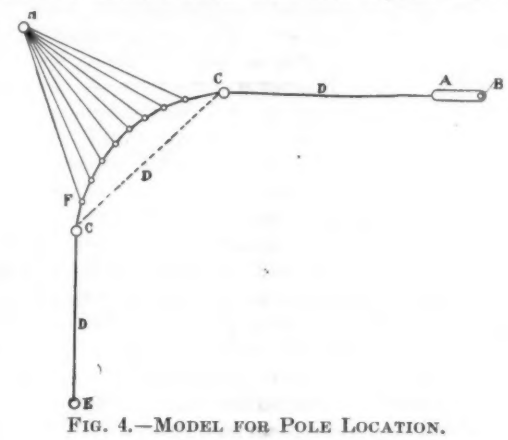


FIG. 4.—MODEL FOR POLE LOCATION.

in the track. Turn-out switches should be located in the same manner.

This chapter would not be by any means complete without speaking of the most excellent manner of curve building devised by Mr. Sidney S. Short, of the Short Electric Company.

Two poles *A*, Fig. 6, are set on opposite curves, and a heavy span wire run between them, and insulated from the poles by circuit breakers. Short pull-offs are then run to the trolley wire from the span wire.

All poles for electric railroad lines should be set either in concrete made of Portland or Rosendale cement, sand

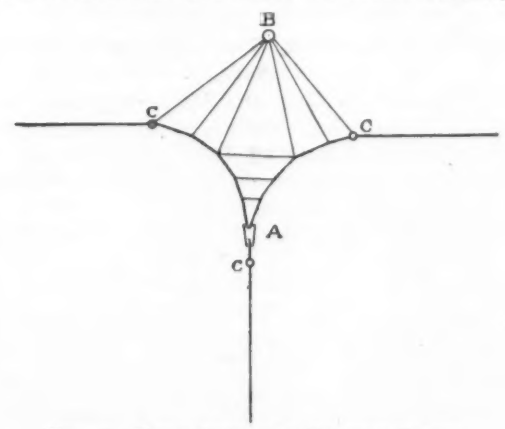


FIG. 5.—PULL-OVER FOR DOUBLE CURVE.

and broken stone; or, in case of bracket or centre pole work, they may be set in cobble-stones and earth. The earth in the latter case should be well tamped by means of wooden or iron tamps.

One of the best ways of setting the poles after the holes are dug is by the use of a tower wagon, which is made according to Fig. 7. To the body of a wagon are fastened four uprights, the tops of which should reach 19 feet above the ground; and these are stiffened by the four braces, which are made of hemlock about six inches wide and two inches thick.

Across the two front uprights run boards, which form a ladder, and this enables a man to ascend to the platform, which is about 7 feet × 4 feet 6 inches, and has a slight bulwark around it one foot high and lockers on each side for tools. At 12 feet from the ground is the arm, which is securely fastened at two points. A winch is fastened to the body of the wagon, a little back of the centre. A rope leading from this is led through a snatch block, and is fastened to the pole a little above the centre of gravity.

By this means a pole may be set in a very short time by three men. After the pole is in the proper position and the proper rake given it by means of a spirit-level, which should have a taper on one edge, it is held in place by pike poles and the cement packed in around it. This concrete should be made in a large dump cart, which can be driven from one hole to the other, and the cement shoveled directly into the holes, and well tamped in around the poles.

About a week after the poles are set the arms should be attached; and this may be done by means of the tower wagon or by men using ladders, depending largely on the nature of the arm used. The ladder should be five feet longer than the pole and should be lashed against it top and bottom. A snatch block is attached to the upper rung and a rope run through it, by means of which the arm is raised,

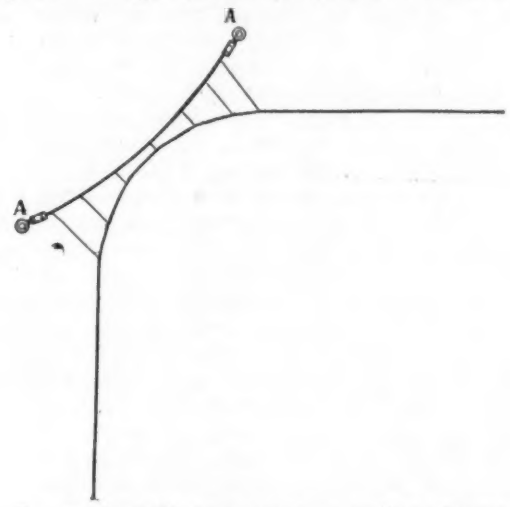


FIG 6.—SHORT'S ARRANGEMENT OF PULL-OVERS.

one man being at the top of the pole to guide it into place and fasten it there with bolts. All pins, etc., should be attached to the arm before it is put in place. The feed wire is next run, but the manner of doing this will be described in another article.

The Magnetic Circuit of Transformers: Closed Versus Open.*

BY S. EVERSHED.

(1) The alternate current transformer has led a curious dual existence since its appearance in this country, some ten years ago. Not having had the advantage of English

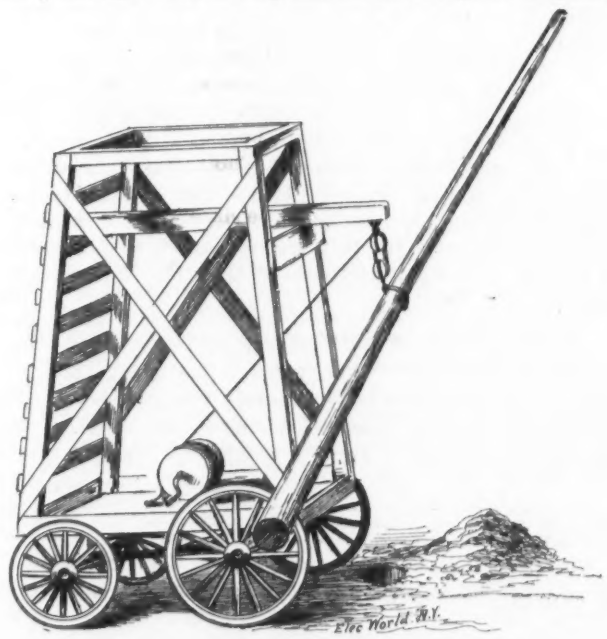


FIG. 7.—WAGON FOR POLE ERECTION.

parentage, it was necessarily regarded somewhat askance, especially as claims were made for it amounting to thinly veiled perpetual motion. However, when it occurred to some one to use transformers in parallel we quickly adopted it, and since that time it has been a mainstay in all lighting schemes covering large areas. Having adopted it as one of our own children, the first thing to be done was to provide it with a complete suit of mathematical clothing; accordingly Prof. George Forbes supplied his "Formulæ for Converters," Mr. Kapp settled the proportions of iron and copper, and nothing remained to be done. Practical men for the most part took no notice of these more or less mathematical essays, or, if they did, declared the clothing to be a misfit; while the mathematicians urged that the transformer ought to be squeezed into the garments provided for it at any cost. Future students of the history of the transformer at this time will probably recognize two entirely distinct types: the ideal or phantom transformer, and the transformer which runs lamps; the phantom being chiefly remarkable for the number of its constant coefficients and for its usually immaculate iron core, while the transformer engaged in actual work, haply unconscious of *L* and *M* could not keep its iron cold, and showed a distinct tendency

*From the *Electricia* London.

to weakness in insulation. In short, the phantom and the real have developed side by side without any clearly apparent relation between theory and practice as cause and effect.

(2) Quite recently an interesting volume has appeared from the pen of Dr. Fleming, in which simple harmonic currents are largely dealt with, and several steps are taken to reconcile the phantom with the real by admitting that there are not one but three sorts of self-induction coefficient, mostly variable, besides a variable coefficient of mutual induction. This is indeed a welcome advance, and goes some way toward the final abandonment of such coefficients altogether in this connection. Matters being in this condition, Mr. Swinburne, who already had a considerable reputation as a maker of paradoxes, electrified the B. A. meeting of 1889 by telling section G that the closed magnetic circuit was a mistake, and that for his part he intended to make open circuit transformers, they being both cheaper and more efficient under all usual conditions as to load. No one being inclined to discuss such a revolutionary proposition, Mr. Swinburne retired to Teddington to prepare "Hedgehogs" and more paradoxes. But he left behind him an uncomfortable suspicion that the "all-day efficiency" of most real transformers was lamentably low, and it cannot be supposed that the matter will be allowed to rest. In fact, the financial success of every alternate current supply company depends, to a large extent, on the all-day efficiency of its converters, so that it is of vital consequence to them to know what design to adopt for any given condition of load. It may be said at once that the problem of determining the best design for a given load is too complex to admit of ready solution, and the writer cannot hope to do more in the present articles than clear the ground by discussing the relative merits of closed and open transformers considered as part of a distribution system.

(3) The waste of energy in the transformers themselves being the key to the whole problem, we will first determine the amount of the various losses which go to make up the daily waste. The only losses of any practical importance are those caused by (1) hysteresis in the core, (2) eddy currents in the core, (3) eddy currents in the coils, and (4) C^2R loss in the coils. Of these the first two are now generally admitted to be the most serious. Having discussed the question of waste in the case of one or two closed and open transformers, quite apart from any consideration as to phases of induction, current and E. M. F., we shall next describe a method by which the periodic curves of these quantities may be drawn so as to give a true diagram of what is going on in a transformer under varied conditions of load.

The mathematical reader will do well to abandon the writer at this point, as in all probability L, M, and other such attributes of the phantom will not be mentioned.

(4) As an illustration of the method adopted in calculating the waste, we will take a 30 h. p. Goolden-Ravenshaw closed transformer, and determine the losses in it at full load. The writer has no reason to suppose this particular type to be either better or worse than others of its class; he simply takes it as an example because, in addition to the dimensions and other data, given in Table I., he has in his possession several cyclic **B-H** curves taken from specimens of the iron from which the cores of these transformers are made.

TABLE I.—THIRTY HORSE-POWER CLOSED TRANSFORMER.

Full load output	= 22·4	kilowatts.
Frequency = F	= 70	per second.
Total volume of iron in core	= 13,700	cc.
Sectional area of iron in core	= 95	sq. cms.
Mean length of magnetic circuit	= 145	cms.
Width of core plates = b	= 15.2	cms.
Thickness of core plates = t	= .05	cm.

	Primary.	Secondary.
Volts	2,000	100
Turns on coil	680	34
Resistance	.97 ω	.003 ω

Hysteresis Loss.—This is found from the area of the **B-H** curve, taken between the maximum **B** on each side of zero, and

$$\text{Maximum } \mathbf{B} = \frac{9\ E.\ 10^8}{10.4\ N\ A\ F} \qquad (1)$$

Here and throughout these articles E is *effective* E. M. F. in volts; so also C will always stand for *effective* current in ampères. E and N may be either the primary or secondary E.M.F. and turns; preferably the latter, the secondary being nearest the core. To reduce E to average E. M. F. we have used the coefficient $\frac{9}{10}$.

Putting the values given in the table into (1) we find maximum **B** = 10,000 gausses. The cyclic **B-H** curve between + and — 10,000 gausses is given in Fig. 1. Its area, measured by a planimeter, is 81,600 gauss-dynes, which, divided by the ubiquitous 4π gives the loss in ergs per cubic centimetre per cycle.

5. An elementary proof of this well known relation between the area of a cyclic **B-H** curve and the loss of energy may not be amiss. Suppose such a cyclic curve as that shown in Fig. 1 to be taken from a ring of iron one square centimetre in sectional area, and l centimetres in mean length. Let the magnetizing coil have N turns, so that

$$\mathbf{H} = \frac{4\ \pi\ NC}{10\ l}$$

where C stands for current in amperes, take any point, P, on the rising curve, and consider what happens when **B** increases by a small amount δ **B** during a short time δt; **H** has the value $\mathbf{H}_2$ during this change. What is the work done by the current on the iron during the time δt? The back E. M. F. in the magnetizing coil is $N \frac{\delta \mathbf{B}}{\delta t}$; the current corresponding to $\mathbf{H}_2$ is $\frac{\mathbf{H}_2 l}{4\pi N}$; the product of these factors multiplied by the time is the work done, or

$$\text{work done} = \frac{\mathbf{H}_2 l}{4\pi N} \times N \frac{\delta \mathbf{B}}{\delta t} \delta t = \frac{\mathbf{H}_2 l}{4\pi}\ \delta \mathbf{B}.$$

Now when, during the time the current is falling, the induction diminishes by δ **B** at the point Q, **H** is only $\mathbf{H}_1$, and the energy returned by the iron to the circuit carrying the current is $\frac{\mathbf{H}_1 l}{4\pi} \delta \mathbf{B}$, so that $\frac{l}{4\pi}(\mathbf{H}_2 - \mathbf{H}_1)\ \delta \mathbf{B}$ is lost in the iron. When δ **B** is very small $(\mathbf{H}_2 - \mathbf{H}_1)\ \delta \mathbf{B}$ is the area of the little parallelogram P, Q; and as the whole cyclic curve can be divided into such little areas, the whole loss in the ring is

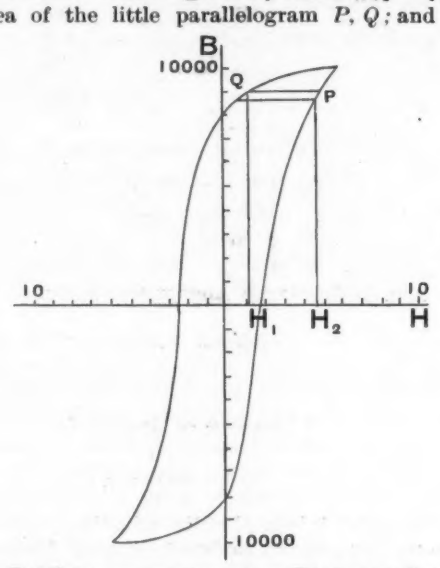


Fig. 1.—**B H** Curve taken from Charcoal Iron used in Ravenshaw Transformer.

$$\frac{l \times \text{area of } \mathbf{B}\text{-}\mathbf{H} \text{ curve}}{4\pi};$$

and since there are l cubic centimetres of iron in the ring, the loss per cubic centimetre is clearly

$$\frac{\text{area of } \mathbf{B}\text{-}\mathbf{H} \text{ curve}}{4\pi} \text{ ergs per cycle.}$$

It will be noticed that no distinction is made between the induction in the iron and the induction which would have threaded the coil if the iron were absent, thus departing from the highly artificial and confusing custom of dividing **B** into **H**, plus another quantity, the meaning of which in the case of a closed iron ring is not clear. To be consistent, those physicists who write $\mathbf{B} = \mathbf{H} + 4\pi\mathbf{I}$ ought, perhaps, when speaking of a copper wire carrying six ampères, to tell us, "the current in that wire is one ampère, which would be there if the wire were iron, plus five ampères 'induced' in the wire because it is not an iron but a copper

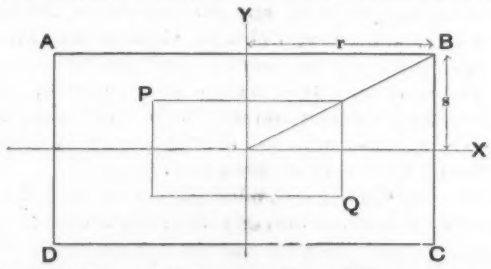
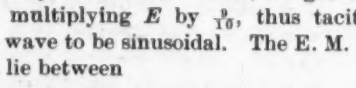


Fig. 2.—Section through Core Lamina normal to Induction Path.

wire." Or again, of a mica condenser, "that condenser holds five micro-coulombs at one volt; but it would hold one micro-coulomb if the mica were absent, so that the total induced charge is only four micro-coulombs." Therefore its capacity is four microfarads!

To resume. The area of the curve in Fig. 1 being 81,600, the loss per cubic centimetre is $\frac{81{,}600}{4\pi} = 6{,}500$ ergs per cycle. The volume of iron is 13,700 cubic centimetres, the frequency 70, so we have for the power wasted on hysteresis,

$$W_h = \frac{6{,}500 \times 13{,}700 \times 70}{10^7} = 625 \text{ watts.}$$

(6) In this calculation we have made two assumptions, which we will now justify, if we can. First, we get the average E. M. F. by multiplying E by $\frac{9}{10}$, thus tacitly assuming the E. M. F. wave to be sinusoidal. The E. M. F. is tolerably certain to lie between the two limiting forms  and ; in the first, or zigzag, the proper coefficient would have been .86; in the second it would be 1; so that the 625 watts cannot be more than four per cent. too high nor 10 per cent. too low; always supposing the generator to give a smooth curve of some sort. We need hardly observe that an error of 5 or 10 per cent. in estimating a loss will make practically no difference when we come to add up all the losses.

Next we assumed a **B-H** curve taken by the ordinary ballistic galvanometer methods to be a faithful representation of what goes on in a transformer core under rapid reversals of magnetic force. In taking **B-H** curves from laminated iron rings of small size, it is obvious that the time taken by the exciting current to reach, say, 98 per cent. of its steady value, must be very short; and, in fact, in obtaining the particular **B-H** curve used in the foregoing calculation, the current necessary to produce an induction in the ring equal to 10,000 gausses must have reached 98 per cent. of its steady value in about one-hundredth second, corresponding with a frequency of 25. This is sufficiently near the frequencies used in practice to make it in the highest degree improbable that the curve so obtained is seriously different from what it would be at three or four times the frequency. Moreover, Prof. Ewing's "model" having put the Weber-Maxwell theory of molecular magnets on a tolerably secure and simple basis, it certainly seems well-nigh incredible that molecular magnets should be incapable of executing forced vibrations at what must, from a molecular point of view, be a very leisurely pace.

(7) At this point we may just touch on the question of the so-called viscous hysteresis. It is alleged that, quite apart from eddy currents and static hysteresis, there is a true time-lag of induction behind magnetizing force. Prof. Ewing has, indeed, observed a time-lag for very small values of **H**, the lag amounting to several minutes; but has such a lag as this anything whatever to do with transformers? No; and for a very good reason. When a **B-H** curve is taken, as was that in Fig. 1, by the ballistic method, the galvanometer gives us the almost instantaneous value of **B** for any value of **H**, and these are the values used in determining the hysteresis loss. As to a lag comparable with such short times as one-tenth to one-hundredth of a second, there is no evidence whatever of its existence, and never will be until eddy currents are entirely eliminated from experimental results.

It is interesting to note that the loss per cubic centimetre per cycle in the iron used for the cores of these transformers is only 25 per cent. higher than that given by Prof. Ewing, so that in practice it is possible to get large quantities of excellent iron requiring no annealing before use.

(8) *Eddy Current Loss.*—In determining this loss in the core of a transformer, we are obliged to fall back on approximate calculation, as, so far as the writer is aware, no reliable experimental determinations have yet been made. In Fig. 2 let the rectangle $A\ B\ C\ D$ be a section through a single lamina of the core, at right angles to the induction path. Assume the direction of the resultant E. M. F. and current in the lamina to be parallel to the edges of the section, then the dotted line $P\ Q$ will be an elementary current path cutting the axes at the values $+x + y$ and $-x - y$, in succession.

Let $\dot{\mathbf{B}}$ be the time rate of change of induction in the lamina, that is $\frac{d\mathbf{B}}{dt}$.

ρ be the specific resistance of the iron.

l be the length taken along the induction path.

Then the E. M. F. round $P\ Q$ is, of course, $\dot{\mathbf{B}}$ (area $P\ Q$), or $4\ \dot{\mathbf{B}}\ x\ y = 4\ \dot{\mathbf{B}}\ \frac{s}{r}\ x^2$ by the assumption we have made with respect to the direction of E. M. F.

The resistance of the elementary path $P\ Q$ is

$$d\ R = 4\ \frac{\rho}{l}\left(\frac{x}{d\ y} + \frac{y}{d\ x}\right) = 4\ \frac{\rho\ r\ x}{l\ s\ d\ x}, \text{ or}$$

we can safely neglect the term $\frac{s}{r}$ in any lamina whose width is, say, 20 times its thickness. The element of power—

$$d\ w = d\ \frac{E^2}{R} = 4\ \mathbf{B}^2\ \frac{s^3\ l}{r^3\ \rho} x^2\ d\ x$$

and the power in l centimetres of lamina is

$$W = \int_0^r 4\ \dot{\mathbf{B}}^2\ \frac{s^3\ l}{r^3\ \rho} x^2\ d\ x = \frac{\dot{\mathbf{B}}^2\ s^3\ l\ r}{\rho};$$

but as $s = \frac{t}{2}$ and $r = \frac{b}{2}$ expression is equivalent to

$$\frac{\dot{\mathbf{B}}^2\ t^2\ .t\ l\ v}{16\ \rho}$$

for a volume of $t\ l\ b$ centimetres, and finally the loss is

$$\frac{\dot{\mathbf{B}}^2\ t^2}{16\ \rho} \qquad (2)$$

watts per cubic centimetres of iron in the core provided **B** is reckoned in volts and ρ in ohms.

This is the loss on the assumption that the eddy currents are constrained to flow in lines parallel with the bounding surface of the lamina. Any artificial constraint of this kind must tend to diminish the calculated loss, so that the true loss will be slightly greater than that found from (2). To get a rough idea of the difference, take the loss in a square wire. Calculated on the same supposition as to direction of currents that is involved in (2), it is $\frac{\dot{\mathbf{B}}^2\ l\ r^2}{8\ \rho} \times$ (area of section), where r is the radius of a circle of the same area as the square wire. It is clear that the true loss must be slightly less than in a round wire of the same area; that is to say, it must be less than $\frac{4\ \dot{\mathbf{B}}^2\ l\ r^2}{\pi\ 8\ \rho} \times$ (area of section), which is the calculated loss in a round wire of radius r. Now this last expression is got by assuming the current flow to be everywhere parallel to the boundary of the circular section, a

assumption which is obviously correct, and therefore the actual loss in the square wire cannot be more than $\frac{4}{\pi}$ times the loss when the currents are constrained. In a thin lamina the "constrained" and the true loss must be very much nearer equality, for in a large proportion of the area of section the currents are constrained by the bounding surface. In short, the result given in (2) must be correct for infinitely thin laminæ, and is sufficiently accurate for all practical purposes. In order to err on the right side we shall make an allowance for the eddy currents in the solid bolts used for clamping the core plates together; an addition of 5 per cent. will cover this.

(9) When we come to put the values given in table I. into equation (2) the inquiry naturally arises, is $\dot{\mathbf{B}}$ constant throughout the section of a lamina? It is clear that $\mathbf{B}$ itself is not uniform, being least at the centre of the lamina, where the eddy currents have the greatest demagnetizing effect, and before drawing a transformer diagram we must ascertain what extra $\mathbf{H}$ is required to neutralize the negative $\mathbf{H}$ due to eddy currents; in the meantime we cannot make an appreciable error in reckoning $\dot{\mathbf{B}}$, that is $\frac{d\,\mathbf{B}}{d\,t}$, from the secondary E. M. F. Thus, $\dot{\mathbf{B}}$ = effective $\frac{d\,\mathbf{B}}{d\,t} = \frac{100}{34 \times 95}$ = E. M. F. in volts per square centimetre of core, or $\dot{\mathbf{B}}^2 = 9.55 \times 10^{-4}$; $t^2 = 25 \times 10^{-4}$; $\rho = 10 \times 10^{-6}$, and the eddy current loss is $\frac{9.55 \times 25 \times 1.05}{16 \times 10 \times 10^2} = .0156$ watts per cubic centimetre. This, multiplied by 13,700 (the volume of iron in the core), is the total eddy current loss,

$$W_e = 214 \text{ watts.}$$

(10) *Eddy Currents in the Coils.*—One feels inclined to say there are none in a reasonably well-designed transformer. Such as there are, however, are due to the stray induction through the coils outside the core, including the induction in each wire due to its own current; the latter being the more important. This effect has been investigated by Sir William Thomson, who has calculated the loss of power expressed as increased resistance consequent on the varying current density in the wire; but we need not consider the loss of power from this cause in such wires as are used for transformer coils. No doubt, if a large solid wire were used for the secondary the loss might be appreciable; but the secondary of a transformer for 200 ampères would always consist of several small insulated wires wound side by side and coupled in parallel.

(11) $C^2\,R$ *Loss in the Coils* depends on the load; taking the transformer at full load, the secondary current is 224 ampères, primary current 11.2 ampères for the load plus .5 ampère for excitement, or say, roughly, 12 ampères. We have

$$C_s^2\,R_s = 224^2 \times .003 = 150 \text{ watts}$$
$$C_p^2 R_p = 12^2 \times .98 = 142$$

The total drop in volts due to resistance of primary, plus that in secondary, amounts to about 1.25 per cent. at full load.

We can now write down all the losses and find the full load efficiency:

TABLE II.—30 H. P. TRANSFORMER.

	Watts.	Percentage of total power.
Full load output	22,400	95.0
Core, hysteresis	625	2.7
Core, eddy currents	214	.9
$C_p^2\,R_p$	141	.6
$C_s^2\,R_s$	150	.8
Total	23,530	100.0

$$\text{Efficiency} = \frac{22.4}{23.5} = 95 \text{ per cent.}$$

(12) A large transformer like this would only be used in a sub-station, or on a tolerably constant load of not less than 10,000 watts, so that the designer did not consider its all-day efficiency on one or two hours only at full load. When efficiency at or near full load is the only condition to be observed, it is perfectly justifiable to use a large core and a very little copper in order to secure cheapness, and accordingly we find in the case we have taken that, of the total loss, nearly four-fifths is in the core. Altogether this transformer is a good representative of its class, viz., closed type for full load, and it has served to illustrate the way in which the efficiency can be calculated.

(13) Perhaps the clearest way of indicating the differences between closed and open transformers will be to choose one of the closed type of medium size and investigate its efficiency on an average all-day load. Then in imagination pull it to pieces and reconstruct it with a view to getting a higher efficiency, next convert it without any change in its coils into an open circuit transformer, and finally turn it into a rough imitation of Mr. Swinburne's "Hedgehog."

TABLE III.—TEN HORSE-POWER CLOSED TRANSFORMER.

Full-load output	= 7,500		watts.
Frequency = F	= 70		per sec.
Total volume of iron in core	= 6,600		c.c.
Sectional area of iron in core	= 58.5		cms.
Mean length of magnetic circuit	= 112		"
Width of plates = b	= 10.2		"
Thickness = t	= .05		"
	Primary.	Secondary.	
Volts	2,000	100	
Turns on coils	1,120	56	
Resistance	3.8	.0094	

In table III. are given the dimensions, etc., of a Goolden-Ravenshaw 10 h. p. transformer, which shall serve as the victim of this destructive kind of criticism. The core plates being the same thickness as those used for the 30 h. p. size, the hysteresis and eddy current losses will be simply proportional to the volume of iron used, provided the induction is the same. As a matter of fact, the maximum $\mathbf{B}$ is 9,800 gausses; two per cent. less than in the 30 h. p. This is too small a difference to be worth notice in finding the hysteresis loss, but four per cent. may be deducted from the eddy current loss, since it varies as $\mathbf{B}^2$. The output and losses may now be easily reckoned by comparison with table II. They are inserted here for future reference.

TABLE IV.—TEN HORSE-POWER TRANSFORMER.

	Watts.	Percentage of total power.
Full load output	7,500	94.0
Core, hysteresis	302	3.8
Core, eddy currents	99	1.2
$C_p^2\,R_p$	58	.7
$C_s^2\,R_s$	53	.6
Total	8,012	100.3

$$\text{Efficiency} = \frac{75}{80} = 94 \text{ per cent. at full load.}$$

Drop in E. M. F. at full load = 1.4 per cent.

The efficiency at different loads is shown as a curve in Fig. 3. Note that at about one-third full load it is still 80 per cent., so that where so large a constant load could be relied upon the transformer would be reasonably economical.

(To be continued.)

Transformer Distribution.*

BY J. SWINBURNE.

The distribution of electrical power by means of alternating current transformers can hardly be considered to have reached its final state, and though it may be somewhat difficult to say what system will be in general use ten years hence, there is little doubt that present practice will be largely superseded.

The method now in vogue is simple. It consists of running several independent dynamos, each with its own engine. Each dynamo supplies a few high-pressure mains, which branch off and supply transformers placed in the houses, or wherever light is required. This system, admirable for country towns or straggling villages, is hardly likely to be permanent anywhere else. It has many disadvantages. Except that all the dynamos and engines are in one building, it is nothing more than a collection of little independent installations. Each engine and dynamo supplies its own circuits, which are independent of all the others. In cases of a breakdown of an engine or dynamo, and in many cases of the leads, there is a stoppage till new arrangements can be made at the station. In addition to this, great lengths of high-pressure conductor are required, and this leaves openings for breaking down of insulation. The introduction of high pressures in private houses is dangerous if not well managed, and is in any case expensive, demanding compliance with all sorts of regulations, rendered necessary for the security of the public. The greatest drawback to the present system, however, lies in the waste of power in the transformers themselves. For a long time transformers were supposed to have an efficiency of about 98 per cent. More will be said on this subject presently.

It must be borne in mind that, in spite of the drawbacks of the present system of putting transformers in houses, it may be, and probably has been, advisable for electric light companies to begin on that system, even in such places as London; but I do not think such an arrangement will pay in the long run, and a time will arrive when the mains will have to be changed and a low-pressure supply system substituted. When an electric light company begins, it has to take on houses here and there, where it can get them, but if its district is populous and wealthy, it should soon be enabled to work on some low-tension or sub-station system; and then the question is whether it is not better to lay the low-pressure mains at first, instead of beginning on one system and changing to another. Probably none of the existing companies mean to change from one system to another. Their engineers have no doubt gone into the merits of the particular cases, and have come to their conclusions with great deliberation, and I do not think it well to offer any criticisms lightly.

PARALLEL RUNNING ACCORDING TO ORTHODOX HYPOTHESIS.

To begin at the beginning of my somewhat extensive subject, the first question is that of running machines in parallel. There are few matters of greater importance to engineers, and few on which opinions differ so widely. One says that machines will not run in parallel unless they have large self-induction; another that it is necessary to have iron in the armatures; another that they will only run together if they have no self-induction, or as little as possible. Others say that there is no difficulty in running them in parallel. No engineer who employs direct currents denies the advantages of running machines in parallel. If independent running is advisable in alternate systems, it is equally advantageous in the case of direct currents, and direct current stations should have separate circuits for each little district, each district being run by one dynamo. I do not think, therefore, independent running is advisable.

In 1884 Dr. Hopkinson showed that alternate-current dynamos could be run in parallel, or could be run as dynamo and motor, and even that a machine giving a high pressure could be run as a motor off a circuit of lower pressure. In his paper he assumes that machines have self-induction. He points out that the self-induction varies, but that it would be impossible to work out the calculations if the self-induction were taken as variable. For some reason or other, Dr. Hopkinson's calculations have received little application. That is to say, engineers have not taken actual cases and worked them out. Calculations have been made in which the various quantities have appeared in the form of letters, and diagrams have been drawn in which they are represented by lines whose lengths have been chosen at random. The geometrical treatment of many problems of this kind shows most of the actions very clearly to students, but is not always of value in practical work, as in most cases some lines are so long and others so short that it would be difficult to avoid large errors. The result of this is that few of us, if any, have had a definite idea of how much self-induction a machine should have to make it work well in parallel with others. The general impression is that it is somewhat difficult to design a machine whose self-induction is large enough, and that most failures to run in parallel are due to deficiencies in this respect. I am using the term "self-induction" under protest, as I prefer to look at the question from another point of view. But whatever goes on in a dynamo if the no load electromotive force is treated as constant, a value for a constant coefficient of self-induction can be assumed which will produce results somewhat similar to those found in practice. To overcome the difficulties arising from deficient self-induction in the armature circuit, Dr. Hopkinson has proposed to insert it artificially, in the form of choking coils, or to use induction couplers to compel synchronism. Without knowing that it had been done before, I described a similar arrangement to the institution a few years ago.

In the spring of 1890 Mr. Mordey read a most important paper, in which he described some experiments on alternate machines. He argued from them that self-induction was deleterious, and that machines would run together best if they had none. In the discussion, Dr. Hopkinson pointed out that the experiments were quite in accordance with his theory, and that there was nothing that could not be foretold by it.

To begin with, it is necessary to get a clear idea of what is required for parallel running. It is not exactly the same as the case of alternating motors, neither is it the same as two machines of equal pressure coupled in parallel by themselves. If all the machines are coupled to two main conductors, we may consider them one at a time, and take each dynamo as coupled to a system whose pressure and variations of pressure are independent of it. Suppose the effective pressure to be 2,000 volts, for example: we have to consider a pair of mains with 2,000 volts, and we have to couple on a dynamo to add so many ampères to it. Such a machine must not be excited to give 2,000 volts on no load, being then thrown into circuit with full steam turned on immediately afterward. It should be excited to give somewhere about half load with 2,000 volts at the terminals, and should then be thrown in. Steam can then be turned on, and the excitation raised to its normal value. The machine should be so designed that any excessive power that the engine may give shall not only not throw the machine out of step, but shall not increase the armature current to such an extent as to damage the insulation by excessive heating.

The power absorbed by a dynamo working on a parallel system is

$$P = \frac{B^2\,r}{2\,i^2} - \frac{A\,B\,r}{2\,i^2}\cos 2\,\pi\,n\,t + \frac{A\,B\,L}{2\,i^2}\sin 2\,\pi\,n\,t,$$

where A is the maximum station electromotive force—that is to say, the station pressure is $A \sin 2\,\pi\,n\,t - B$ is the maximum "impressed" electromotive force in the armature, r is the armature resistance, i the impedance of the machine, and τ the angle of lead. This equation is taken from Dr. Hopkinson's paper. When the dynamo is doing its proper share, that is to say, under normal conditions,

$$B = I\,c;$$

where I is the impedance of the whole circuit when the machine is isolated, and working at full load on an external resistance, and c is the maximum value of the current. To find how much the driving power may increase for a small increase of current, we may differentiate with respect to c, and then find the value of L, which makes the result a maximum.

$$c = \sqrt{\frac{A^2 + B^2 - 2\,A\,B\cos 2\,\pi\,n\,\tau}{i^2}}.$$

$$\text{Cos } 2\,\pi\,n\,\tau = \frac{A^2 + B^2 - i^2\,c^2}{2\,A\,B}.$$

So

$$\frac{d\,P}{d\,c} = \frac{A\,B\,r}{2\,i^2}\cdot\frac{i^2\,c}{A\,B} + \frac{A\,B\,2\,\pi\,n\,L}{2\,i^2}\cdot$$
$$\frac{d\sin 2\,\pi\,n\,\tau}{d\,2\,\pi\,n\,\tau}\cdot\frac{d\,2\,\pi\,n\,\tau}{d\cos 2\,\pi\,n\,\tau}\cdot\frac{d\cos 2\,\pi\,n\,\tau}{d\,c};$$

and in the case of a dynamo working on resistance, or on

* A paper read before the Institution of Electrical Engineers, London.

a station load when supplied with just its right share of power,

$$\cos 2\pi n\tau = \frac{A + \tau c}{B},$$

$$\text{and } \operatorname{cosec} 2\pi n\tau = \frac{B}{Lc}.$$

So
$$\frac{dP}{dc} = \tfrac{1}{2}A + c\tau,$$

c being the maximum, not the effective, current. It will be observed that L has disappeared altogether.

This shows that for a very small increase of power the increase of current will be the same, whatever the self-induction of the machine may be. It would not matter if the machine had none. A machine with no self-induction would (Mr. Mordey notwithstanding) short-circuit the mains if the engine supplied too little power; in fact, at full load it would be giving its minimum possible output, and any attempt to diminish this would be disastrous.

Discussing the question of a very small increase is not exhaustive; an engine may supply a large proportion more than its share of power to one machine. For instance, suppose it supplies twice the normal power. Many engines could not give such an excessive power, but in others, which have expansion gear controlled by a speed governor, it is easy to get double power if the station is running at a slightly slower speed than that for which the governor is set.

These matters are always made much clearer by taking practical examples and working them out. The great difficulty is to obtain accurate data. I should prefer to discuss such machines as those described in Mr. Mordey's paper read here a short time ago. Without wishing to say anything in disparagement of his excellent paper, I must point out that an account of experiments should contain full particulars of the machines on which the experiments were made. Such omissions are exceedingly common in electrical papers. Mr. Mordey has not given us the details of the field magnets, air space, armature coils, or exciting coils; he has not even given us the currents in the different experiments. I have found similar omissions whenever I have tried to gain information from any of the numerous experiments which have been made on alternate machines in America. Mr. Mordey does, however, say that about half the drop in his machines is due to resistance, and half to self-induction. The machines give an output of 2,000 volts and 20 ampères, and when fully excited give 2,200 volts at no load. This would correspond to a self-induction of 0.05 henry.

Suppose, first, that the self-induction were such that $2\pi nL = r$. On increasing the power supply the effective current increases evenly, and when the power supplied to the machine is doubled the effective current is only about 44 ampères. It is necessary, however, that the machine should stand decrease of load, as well as increase, without injury. Keeping the same self-induction, let us decrease the load to zero with the full excitation on. The current gradually diminishes to just below 15 ampères, and then increases to just over 20 again.

These figures are extremely troublesome to work out from Dr. Hopkinson's equations, as the angle is so small that an error in about the sixth place of decimals will vitiate the results.

Many people prefer diagrams such as those used in mathematical books when dealing with harmonic variations. Mr. Blakesley has applied these diagrams to the discussion of alternate dynamos and motors, and Messrs. Kapp, Fleming and others have applied them too. The

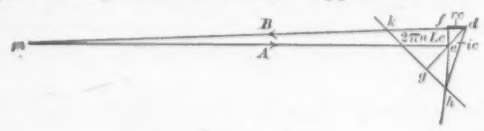


FIG. 1.

chief drawback is that it is not always easy to draw such figures to scale. They are generally drawn with the values taken at random to give ideas of the principles involved. So far as I know, no scale diagram of this sort has ever been published. In the case of the 40,000-watt machine such diagrams can be applied; but with 100,000 machines, which will probably be the standard size, the diagrams are almost illegible.

Fig. 1 is a diagram to scale. The lines are all rotating positively. The diagram is made as follows: The pressure in the mains, A, is drawn first. Instead of the maximum, it is simpler to draw the effective pressure—in this case 2,000 volts. From the end e, $2\pi nLc$ is drawn at right angles to it to f; and then rc from f, parallel to A, B is drawn to join the ends of A and rc, as shown. The lines are all pressures; but the instantaneous current is in step with the pressure rc and with the pressure A, so that the power is proportional to $Brc\cos fdm$. I use the expression "in step" to mean co-phasally synchronized. Thus two machines may be running at the same speed without being in step; just as soldiers may take the same number of paces per minute without being in step.

To find the current at double load, produce ic to g, so that $dg = 2ic$. Through g draw a straight line, cutting B at k, at an angle gkd, equal to the angle def. The line gk is the locus of the end of the line representing the pressure spent over the resistance and self-induction of the armature with currents giving double load. It is unnecessary to go into the proof of this. With m as centre and A as radius, describe arc cutting kg at h; join dh. Then the current at double load is to 20 ampères as dh is to de. In this case the double-load current is not much more than 40 ampères.

To find the current at half-load, bisect de, and through point of bisection draw a straight line parallel to hk, and proceed as before. The no-load line, of course, passes through d.

Let us now assume the self-induction to be 0.05. The resulting diagram is shown in Fig. 2. The double-load current is almost exactly 40 ampères.

Take now the case of a 40,000-watt machine with a self-induction of 0.1. At double load the current is 50 ampères and at no load it is only 1.6 ampères. If the machine has a self-induction of much more than 0.1 quadrant, the current at double load begins to increase rapidly. It is thus clear that the self-induction may have any value between 0.008 and 0.1 and the machine will work perfectly in parallel.

We have only taken small machines. Mr. Kapp recently described a 60,000-watt machine with an armature resist-

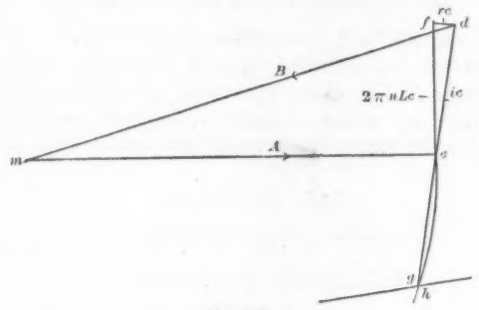


FIG. 2.

ance of 1.74 ohm, and a self-induction of 0.0955—say of 0.1. We may see how it will work in parallel. The pressure is 2,000 volts, and the frequency 80. This case cannot be shown clearly in a diagram, as rc is very small in comparison with $2knLc$ or B. The result is, however, that the machine cannot possibly take double power from the engine; it falls out of step first. Now 60,000 watts is not a large output for central stations, and it is probable that 100,000 will be about the size adopted. The "time constant" of such a machine is considerably greater. We thus find that, according to the self-induction hypothesis, the difficulty does not lie, as commonly supposed, in getting enough self-induction in the armature; the trouble is that there is generally too much. But in machines from 55,000 to 50,000 watts, it is exceedingly difficult to make dynamos that will run perfectly in parallel, so great is the permissible margin of self-induction. It must be carefully borne in mind that so far the armature has been supposed to have a constant coefficient of self-induction, and the pressures of current are assumed to vary harmonically.

The orthodox hypothesis thus tells us that with ordinary sizes of machines it is exceedingly difficult to design them so that they will not run in parallel. Either, therefore, all ordinary machines run perfectly in parallel, or the assumption that alternating currents follow sine laws, that machines have coefficients of self-induction constant throughout each period, or that they have coefficients of self-induction constant for different armature currents, is too far from the truth to be useful; or, in legal language, one, or some, or any, or all of them must be wrong.

PARALLEL RUNNING ACCORDING TO ARMATURE REACTION THEORY.

Last year I had the honor of reading a paper before this institution on armature reactions in direct-current machines. In it I showed how the performance of large machines could be foretold; and the whole question of the effect of the armature current on the field magnets was discussed with some minuteness. I cannot pretend to treat alternate-current machines with the same exactness, but still a great deal is to be derived from the study.

It has sometimes been assumed that a machine has self-induction in the armature, and also that there are armature reactions to be considered, and the two actions are treated as if their joint effects had to be taken into account. This view is, I submit, erroneous. Imagine a battery with its cells connected to a number of contact pieces, and imagine the middle cell connected to a terminal, to represent one terminal of the machine, and the other terminal represented by a rubbing contact which is moved backward and forward over the cell contacts by a crank and connecting rod. This gives the analogue of a hypothetical machine with no self-induction. If a choking coil is put in circuit, the hypothesist's alternating machine would be produced. To get a constant coefficient of self-induction in a real machine would be almost impossible. If a coil passes between two cheeks of laminated iron, its coefficient of self-induction is constant. In a dynamo, however, half the iron is cut away, the remainder forming the pole-pieces, and this remainder is not laminated. Even if a dynamo gave a curve of sines at no load, therefore the reasoning already given would not be accurate, as L would vary considerably from one part of the period to another.

The term "self-induction" is also used somewhat loosely. Engineers do not generally think of electrical inertia now. By a self-induction 1 in an electric circuit is meant that if there is a current of 1 in it, it is interlinked with one line of induction. The idea of self-induction is naturally inseparable from the notion of magnetic induction being interlinked with the circuit. Another way of looking at it is to say that if the current increases there is a back electromotive force proportional to the rate of growth of the current and to the self-induction of the circuit. In an alternate dynamo the first definition is meaningless, because there is a field produced by the magnets; so, when the machine is still, there may be a large number of lines of induction through the armature coils without any armature current. If the second definition is taken, there is likewise an electromotive force produced by the passage through the field, apart from the effect of the armature current.

(To be continued.)

The Inventions of Thomas Davenport.*

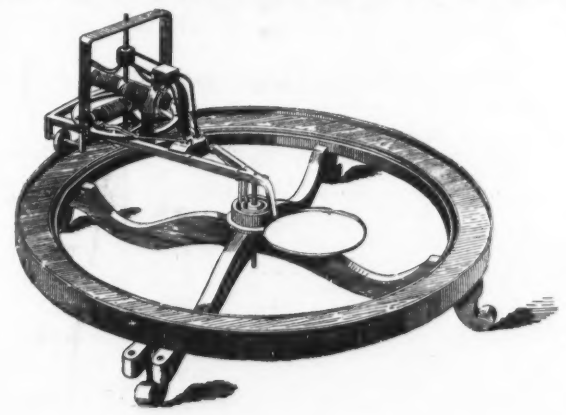
BY FRANKLIN L. POPE.

The year 1837 marked a very important era in the history of the industrial development of electricity. During that year two of the most extraordinary inventions of the present century made their advent in this city—the electric telegraph of Prof. Samuel F. B. Morse and the electric motor of Thomas Davenport. The motor came first. Davenport, a self-taught Vermont blacksmith, who had invented and constructed his machine in a remote country village in a crude form as early as 1834, came to New York in February, 1837, bringing with him some of the machinery which had been made for the purpose of exhibition, by himself and Ransom Cook, with a view to enlisting capital to build a large motor. During the season of 1837 he occupied rooms in the city, where he exhibited models of his motor and various other electrical inventions. Articles were published in the newspapers of the day, and his exhibitions were attended by a great number of people. In letters written about that time, Davenport mentioned that one of the most frequent visitors was Professor Morse.

With the history of Professor Morse and his invention of the telegraph the world is quite familiar. With the history of Davenport and of the invention of his electric motor—as I soon discovered in endeavoring to obtain information about it myself—scarcely anything was known. This difficulty ultimately led me to interest myself in trying to find out more about the matter. In this undertaking I was fortunately very much more successful than one can reasonably expect to be, in attempting to resuscitate the history of an invention which has lain unknown for the best half of a century.

The first newspaper notice of the electric telegraph which appeared in America was in the *New York Observer* in the summer of 1837. I will read you an extract from it:

"A gentleman of our acquaintance several years since suggested that any intelligence might be communicated almost instantaneously hundreds, if not thousands, of miles by means of very fine wires, properly coated to protect them from moisture, and extending between places thus



DAVENPORT'S ELECTRIC RAILWAY.

widely separated. It is well known that the electric fluid occupies no perceptible time in passing many miles on a wire, and if it is possible by connecting one end of the wire with an electric or galvanic battery to produce *any sensible effect whatever* at the other, it is obvious that if there are twenty-four wires, each representing a letter of the alphabet, they may be connected with the battery successively in any order, and if so connected in the order of the letters of any word or sentence, that word or sentence could be read or written by a person standing at the other end of the wires. All the paragraphs of a newspaper could thus be touched by a man in Philadelphia, and the contents, *verbatim et literatim*, conveyed to New York as fast as a compositor could set up the type."

It has always been a mystery to me what invention was referred to in that article. The *New York Observer* was edited at that time by a brother of Professor Morse. The "gentleman of our acquaintance" referred to was no doubt Professor Morse, but what was meant by the telegraph of twenty-four wires I could never make out, because we all know that Morse never entertained any idea other than that of a single-circuit telegraph at any time from the beginning of his experiments in 1835, or earlier. But I received a few days since a letter from a gentleman who had read some articles recently published by me in reference to Davenport's work, in which he stated that he visited Davenport's exhibition in the summer of 1837, here in the city of New

*A paper read before the American Institute of Electrical Engineers.

York, and that he himself saw in that exhibition a model of a telegraph of twenty-four wires invented by Davenport, and that model must undoubtedly be the telegraph referred to in the extract I have just read.

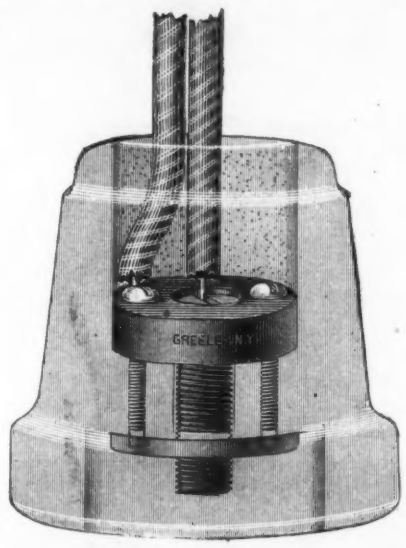
In pursuing my investigations into the history of Davenport's work, I was fortunate enough to find that several of his original models were still in existence. One of these models, a circular railway two feet and a half in diameter with a locomotive traveling on it, similar to the one which we have here to-night, but very much more finely finished, I was able to satisfy myself by contemporaneous evidence was built in 1837. The one which is before you was found in the cabinet of the Female Seminary in Troy, formerly Miss Willard's. The records of the institution show that it was purchased in 1840, but it evidently must have been built by Davenport himself prior to the more finely finished model of which I have just spoken, which was constructed in 1836-7 with the assistance of Mr. Ransom Cook, of Saratoga, a very ingenious person and a finished mechanic. I think there is no doubt that the model before us was built in the early part of 1837 and possibly as early as 1836. Fortunately it is, as you see, in a very good state of preservation. I have had it mounted to-night with the same battery that was found with it—a three-cell Grove battery of pint cups, and I think we shall find that it is in tolerably fair running order. (The model was set in motion.) It does not go quite 120 miles an hour, but it goes. This locomotive, you will observe, has a fixed field magnet below, and a revolving armature above, which is reversed twice in every revolution. So far as I am able to discover, that is a combination found in every practical motor to-day, which Davenport was the first to make known and to use in 1834. The motor is connected to the driving axle by bevel gear. The field magnet and armature in the model before you are connected in series. In the other model of 1837 of which I spoke, they are connected *in shunt*. Among other models of Davenport was one having a horseshoe field magnet and a four-pole armature with curved pole-pieces, which is really quite an advanced type of motor. That was also built in 1837. Altogether, Davenport, between 1834 and 1840, built over 100 motors of different patterns and of varying sizes, scarcely any two of them alike. I discovered also, quite to my surprise, that he was undoubtedly the first to make use of the solenoid with a movable core as a means of moving machinery of any kind. He built in 1839 quite a large motor operating upon that principle, which from the best description I have been able to find of it must have approached 1 h. p. He set that up at 42 Stanton street, in New York; attached a printing press to it and started to publish the pioneer electrical journal of America—a small weekly paper called *The Electro-Magnet and Mechanics' Intelligencer*, printed by electrical power. Through the kindness of Mr. Davenport's son, Rev. Willard G. Davenport, I have the pleasure, on his behalf, of presenting to the American Institute of Electrical Engineers two copies of that paper. These, so far as is known, are the only editions ever published: they are number one and number two. This was in 1840. I have received within a day or two an interesting letter from Mr. H. S. Davenport, a nephew of Thomas Davenport, still living in Vermont at an advanced age, who, as a boy, was with him a great deal and in that way became quite familiar with his work. I will take the liberty of reading extracts which give some idea of the manner of man Mr. Davenport was. He says:

"Many of his models never left his shop and were but little known even at the time of their construction. They were only made to show to how many uses the power could be applied, and also to work from on a larger scale, if he could get pecuniary aid to do so. The different models which interested me most, at the several times I was in his shop, were a trip-hammer, a turning lathe and a machine for doubling, twisting and reeling cotton or silk, all at the same time. A circular frame fitted with two intersecting tracks, on which four miniature cork images glided around, he called his "puppet show." He was naturally of a retiring disposition, but when waked up was very strong in argument. His two favorite subjects were nature, and electro-magnetism. He considered magnetism the most important element in the creation of the universe, and thought it would be in its destruction. Magnetism kept the heavenly bodies in their places, and if that failed everything would be turned to chaos. He could see in every rock of the earth the battery of which it was composed. So also in the animal kingdom, the bones, muscles and blood constituted a complete battery, which exercised a repulsive or attractive force with respect to another organism of the same kind. He was a great lover of fun and exceedingly fond of a joke. On one occasion he received an order from a party in Chicago for half a dozen bottles of electricity. He said he knew by the tenor of the letter that it was intended as a joke, and he accordingly replied that he bottled up his *wrath* for such would-be ignoramuses as he was, but had no electricity for him.

I might go on and relate many other facts of interest which I have learned about Mr. Davenport and his inventions, but the hour is already late, and I will forbear. But I may remark, in conclusion, that I find him to have been one of the most interesting characters with whom I have ever become acquainted, and I cannot but feel highly gratified that my attention chanced to be directed to the subject in season to rescue at least some of the more important of his work from impending oblivion. In two or three years more it would have been too late. There are people now living, although at an advanced age, who knew him and remember him perfectly, but in a year or two more perchance they will be gone.

A Waterproof Socket.

The Cartwright socket, shown in the accompanying illustration, has some commendable features. The porcelain itself, which forms the shell of the socket, instead of being of the common porous article, merely glazed over, is a thoroughly vitrified substance, completely impervious to moisture. The metal parts are fastened to the porcelain



WATERPROOF SOCKET.

frame and do not depend for their security upon the sealing compound. The sealing compound itself is of a quality that will stand a zero temperature without deterioration, and at the same time will admit of the heat that results from a three-ampère lamp without softening, although it is designed simply to meet the requirements of lamps of one-half to one ampère capacity.

The Cartwright waterproof socket, which is put upon the market by The E. S. Greeley & Co., of this city, is made in three patterns for lamps of the Edison, Thomson-Houston and Westinghouse types. They are made, as shown in the illustration, with rubber insulated terminal wires projecting several inches from the shell to admit of rod connections.

Grease Tubes for Loose Pulleys.

The accompanying illustration shows the method of attaching the "magic" grease tubes to loose pulleys, as manufactured by the Lunkenheimer Brass Manufactur-

GREASE TUBE FOR LOOSE PULLEY.

ing Company, Cincinnati, O. A ¾-inch hole is drilled through the centre of the rim, and to correspond with it a ¾-inch hole through the centre of the hub to the bore of the pulley. This latter hole is then tapped to receive the threaded end of the tube. The grease tube is then screwed into placed and filed off so as to be flush with the face of the pulley. A groove is cut across the bore of the pulley to within one-eighth inch of the ends of the hub extending across the hole into which the tube is screwed, as shown in the illustration. The grease candle, which is made to fit the tube, is inserted, and the follower, which fits the threaded interior of the tube, is inserted at the back of the candle. Two or three occasional turns of the follower keep the grease pressed down against the inner end of the tube at the bearing surface, and the groove along the inner surface of the bearing filled with the lubricating material. When the lubricant has become exhausted and the follower has reached the bottom of the tube, this latter may be removed by screwing it in the opposite direction; and another supply of the same material inserted.

Discussion of Mr. O. T. Crosby's Paper on High Speed Electric Railway Work.

After the conclusion of Mr. Crosby's paper, the discussion was opened by Mr. W. H. Pierce, who said: I would like to ask Mr. Crosby if he has made any calculations or estimates as to how far and how long the train would run before it would attain a speed of 150 miles, and how far it would have to run before you can stop it?

Mr. CROSBY: I did make calculations as to the attainment of the speed, and the matter of stopping it I expressed in the paper. I knew that the figures could not remain in the minds of those hearing the paper. The space for stopping, with a braking power that would just fail to slide the wheels, would be just about 7,000 feet, and the time would be in the neighborhood of 100 seconds. The time of getting the train to speed, with the motors as designed, I have forgotten now, but it is in the neighborhood, I think, of two or three miles.

I should say that I do not think there is anything whatever in high speed work for say, even 40 miles. I do not think you can properly do 120 miles an hour for a run of, say, 30 or 40 miles. It is applicable only to connecting very large cities. I think you could run from here to Albany, if you had the New York Central line to run on; from Albany to Rochester, from Rochester to Buffalo, and then stopping at the principal lake cities. It might be found later on that it would be necessary to make shorter stops; but the first efforts should be made only with very long runs.

Mr. F. L. POPE: In conversation some time ago with a prominent civil engineer, at one time professionally connected with the Lake Shore road, he expressed the opinion that safety from derailment at very high speeds would be best secured by very slightly curving the line of the road just sufficient to cause the flanges of the wheels to bear constantly against one side. With that construction he should expect that any possible speed up to, say, 200 miles an hour, that could be got from the motors, would be perfectly safe. He was led to this conclusion from long observation of the performances on the Lake Shore road of railroad wheels at high speed, on which road, as many of you are aware, some of the best running in this country has been done.

Mr. THOS. D. LOCKWOOD: I have been very much impressed with the facts which have been so clearly furnished to us by Mr. Crosby, and, before I forget it, I should like to add one or two remarks, with regard to what he has just now said—that he does not consider high speed—extremely high speed—or even so low speed as 40 miles an hour to be a very important factor except for extremely long runs. I do not know whether I correctly understood that.

Mr. CROSBY: What I meant to say, Mr. Lockwood, was that I did not think a speed of 120 miles an hour was commercially applicable to making short runs of, say, 40 miles. Suppose we have to stop 40 miles away from New York. I do not think it would pay, even if we were a good-sized city, to establish a service there, aiming at a speed of 120 miles for a very short distance. You would not more than obtain it when you would have to give it up.

Mr. THOS. D. LOCKWOOD: I have worked in various capacities upon railroads, and I have had some experience upon steam locomotives, and such experience as I have had leads me to this statement—that the best speed I have ever known to be made out of an average of a great many trips has been done by way trains where the stations were very close together; and the reason of that is that upon a long run you can obtain a fairly high average without even getting an immensely high speed; whereas upon way trains, where the stations are very frequent, we often have to run at enormously high speed between stations to maintain the time, and that is often when we have runs of only two miles between stops. There is a road I have in mind, in the western part of Massachusetts and Connecticut, on which I have worked—the Housatonic Railroad—and between Pittsfield, Mass., and Canaan, Conn., there are a large number of stations. I have known trains to leave Pittsfield some 50 or 60 minutes behind time, and reach their destination on time. Now that sounds rather fabulous to gentlemen who have not been on locomotives or who have not run locomotives. I heard statements made at meetings of this association some time ago, in which Mr. Ries took part, and it was argued then that a great part of the power saved while running down grade might be used to operate dynamos for lighting purposes. Now that is a very prominent method, but the experience of all locomotive engineers leads them to the conclusion—whatever it may lead persons who have not done that kind of work to conclude—that they want all the power all the time, and they are very glad indeed to get a chance to run down grade once in a while.

I noticed that Mr. Crosby in his paper made no reference to what some 18 months ago was a very prominent issue—namely, the improvement of adhesion by the passing of a current from the wheels to the rails. I recollect in different meetings, social, legislative and litigative, in which I have had the honor to appear both as a spectator and participant, that that issue was made very particularly prominent. Some electricians ascribed it to magnetism, which, in some occult way, escaped from the motor and reached the wheels and from there passed to the rail; and while I do believe that magnetism is going to be one of the great braking powers of the future I do not believe it is going to reach the rails that way. But I see that Mr. Crosby has advanced from the opinion which was, to say the least, popular for a few years. In prior meetings of this institute, Mr. Leo Daft and others have made certain statements—I do not know whether they were deliberately written on paper or made on the spur of the moment in discussion—very strongly assuming that there was such a useful effect; Mr. Ries also was a very prominent advocate of that alleged method of improving adhesion. I do not think there can be any doubt that when heavy currents pass from wheel to rail or between any metallic contacts there is a certain slight adhesive effect. I do not think it has any practical effect upon the adhesion which a train in practice requires. In 1878 that very eminent mechanician, Mr. Stroh, in London, ascertained that in passing even comparatively feeble battery currents between contacts that there was a very decided adhesive effect upon a small scale, and he tried this with a great number of metals and alloys, finding that steel—two contacts of steel—gave the very best effect, as compared with other metals. In the light of what we know now, it is very clear that it was a welding effect; that even small currents in passing through loose contacts developed enough heat to make a weld. Mr. Stroh used a lever with a weight upon one end, and in some of

the experiments the lever had an equally long arm at the other end, and after passing the battery current through those loose contacts, and after placing a weight thereon, it was found that that equal weight would not separate the contacts again. But I am compelled to say from my own practice that I do not believe that such an adhesive effect as may exist has any practical utility, for this reason, among others, that such power as it does exert in holding the wheel on the track is lost by the equally certain fact that it must certainly require as much force to unweld it again so as to admit of the progress of the train.

Mr. Crosby: I may answer that I did not mention the fact in the paper.

Mr. Lockwood: I know you did not, and I wished to ask you whether you had any decided opinion.

Mr. Crosby: Very decided indeed. I do not think there is anything in it at all. I have put myself on record as thinking there is nothing in it—short of such currents as will actually heat to welding. I know of experiments which were never published, but which were made by a man much interested in the subject at one of the great universities of the country, which indicate that in a three or four pound model it took something like 200 ampères to produce any effect, and that was plainly a welding effect, since it showed a clear pitting of the little rail on which this model used to run. Now, the number of ampères used there—certainly 100—was surely out of proportion to the current that is used for any time for transportation. That, perhaps, is like the answer of the mayor who said he did not have any cannon, and, therefore, did not salute his majesty—that was one of his 10 reasons. In this work here described there cannot be, in my opinion, any such grade work attempted as to make necessary a distinction from that of ordinary coefficients, even if it should be obtained by the use of extravagantly high currents. I do not know what would be the biggest grade. It is simply a question of how much you are willing to sacrifice in speed in order to save original expense in constructing your line. It is the same question that is presented to the steam railway engineer. He cuts between the two extremes. I should say roughly now that perhaps a two per cent. grade would be a pretty heavy grade to contemplate for that work on account of the great tax on the motors and the actual requirement of power. Then in the matter of the braking effect I do not know whether Mr. Lockwood meant the return of power from the dynamos as the braking effect which he thought would be useful or not.

Mr. Lockwood: No; I meant the idea of short-circuiting. Such a scheme was patented within the past 10 years. I do not believe it has ever been used.

Mr. Crosby: I did not consider the matter of return of energy to the line, because, as Mr. Lockwood says, they want all the power they can get, and because the number of stops is very small compared with the number of miles run. It might be different, say, on the elevated railway service. It might do to run your motors as dynamos and let them give back the word of retardation into the line. But you make a little sacrifice to do that. That is, you have got to work your motors at lower than saturation point for your normal work. Otherwise I do not see how you can get the electromotive force of the motor high enough to pump back into the line. For that reason I do not think it has any place in long distance work where your stops are one in a hundred miles.

Mr. Edward P. Thompson: I would like to ask if it is your opinion, based upon your experiments, that it is impracticable to run an automatic electric train for the purpose of carrying mail matter and other objects of great value where it is necessary to have high speed? It is even of more importance, it seems to me, to transport such from here to Philadelphia, Chicago and other distant places at a great rate than it is to transport people. A great many of those high speed passenger trains were reduced in speed because it was found that people really did not care to go fast, and because of the wear and tear on the locomotive machinery; and therefore the high speed trains running at over 60 miles per hour were to a great extent taken off both in England and the United States, as fully stated about a year ago in the reports of several railway companies; but if, in practice, they actually could get a speed of 120 or 150 miles an hour, it would be more acceptable, I think, for small express packages and mail than it would be for passengers.

As regards brakes for stopping high speed trains, the principal point is economy. I found in some tests made by me in behalf of a brake company upon a railway in Pennsylvania that if it needs a certain amount of energy to start a train it needs about nine-tenths as much to make an emergency stop. In local or accommodation trains the expense would be enormous, therefore, to so frequently reduce the speed as soon as it reached 120 miles an hour, if the electric current were used as the braking power. In the experiments I refer to the momentum of the train was used for braking, while the electric current was merely the agent for controlling the application of the force of momentum. This force is very cheap and plentiful and even with the crude apparatus employed emergency stops were made in which the cost thereof was simply that of an electric current of two ampères acting for less than one second.

Mr. Crosby: In order to have any kind of service, whether you try it automatically or not, you have got to have it safe enough for a man to be on there. That is, you must not have so many accidents as would make it unsafe for a man to go on there, or your business would be gone. If you have an engineer he can have a man to sit by him and another man by him, and you go on till finally you have a passenger train. I do not consider it practicable to run a train—that is, of size enough to make it commercial—without a man on it. I think the enormous complexity of an automatic system that would take care of the entrance into a city and the departure from a city, and of all the varying conditions of service, without a man on board, is really beyond anything that would stand up. You might put it all down to work and have trains on it, but I think the complexity would soon break it down. As to the desirability of fast trains for passengers I must disagree with the gentleman who last spoke. I see a gentleman from Chicago who shook his head very emphatically when the statement was made that people did not want to travel so very fast. I think the limitation, so far as steam railways are concerned, is the ability of the engine to draw enough cars to accommodate people who want to go at that speed. That is what the New York Central people claim in regard to their limited train to Chicago. They cannot run any more cars and have their engines make the speed that is wanted. People at Buffalo complain that they cannot get the fast service which people going from here to Chicago get. They have wanted additional cars put on, and the railroad company has answered, we cannot put on additional cars without sacrificing what we are aiming at, which is high speed.

Mr. Charles Wirt: I want to go on record as against these fast trains unless we can ride on them. I hope to see things fixed so that I can attend these meetings and get back to my work in Chicago the next day. I can only come in about once in six months now. I ride on trains a good deal, and like to hold my watch in my hand and count the mile posts. I learned one very discouraging thing in doing this, which is, that a train which may make a mile in 60 seconds will average no more than 30 miles an hour, and I would be glad to know whether the ratio of maximum to average speed will be any different for the fast running that we are considering.

Mr. F. L. Pope: I think Mr. Thompson is certainly in error in stating that fast trains have been discontinued by our railroads to any great extent. As a matter of fact, I believe that there has never been a time in the history of the world when there were so many fast trains running in this country, or so many running in England, as there are to-day. I live on the route of the "Bound Brook line," which is certainly, all things considered, doing the best running in this country to-day—perhaps the best that is done anywhere. It is now operating a great number of fast trains, and they are increasing in number every year. Some very splendid running is done on that line. Coming over from Philadelphia only a few days ago, I timed three miles by the posts, the other side of Bound Brook, in two minutes and twenty seconds, which I think you will admit is very good speed for a train of five cars.

Dr. L. H. Laudy: We have with us this evening a prominent railroad engineer, Dr. Dudley. If the Chair will call on him I think he will respond.

The President: Will Dr. Dudley favor us?

Dr. P. H. Dudley: I suppose Dr. Laudy prefers to have me tell you about some of the experiments I have made on the resistance of different trains. Those were made several years ago, and not on as good tracks as we have at the present time. The resistance of the passenger train is given by the formulæ in books as 17 or 18 pounds per ton. I found on the Lake Shore & Michigan Southern Railway and the New York Central & Hudson River Railroad that, with trains of about 250 tons, the resistance was only from 10 to 12 pounds per ton at speeds of from 50 to 60 miles per hour. The resistance per ton is not nearly so great on those long trains as on the short ones. With trains of two and three cars, sometimes it ran as high as 35 or 40 pounds per ton, but with long trains it ran down to about 10 and 12 pounds per ton.

The greatest variable that we find from day to day over the same track and same train is the wind resistance. I found in one special experiment I made in 1878, to see why the New York Central was not able to make its time with its trains, that on a still day, with the schedules they had, they were able to make time, but a wind of 10 or 12 miles would retard the trains so that in running from Buffalo to New York they would lose two hours. The trouble at that time was that the boilers were not large enough to quickly generate the steam required to meet the increased resistance. The trains would run up to a speed just about the capacity of the boiler, and that would limit the speed they could maintain. Therefore when a head or side wind was blowing against them the speed of the train would be reduced very materially.

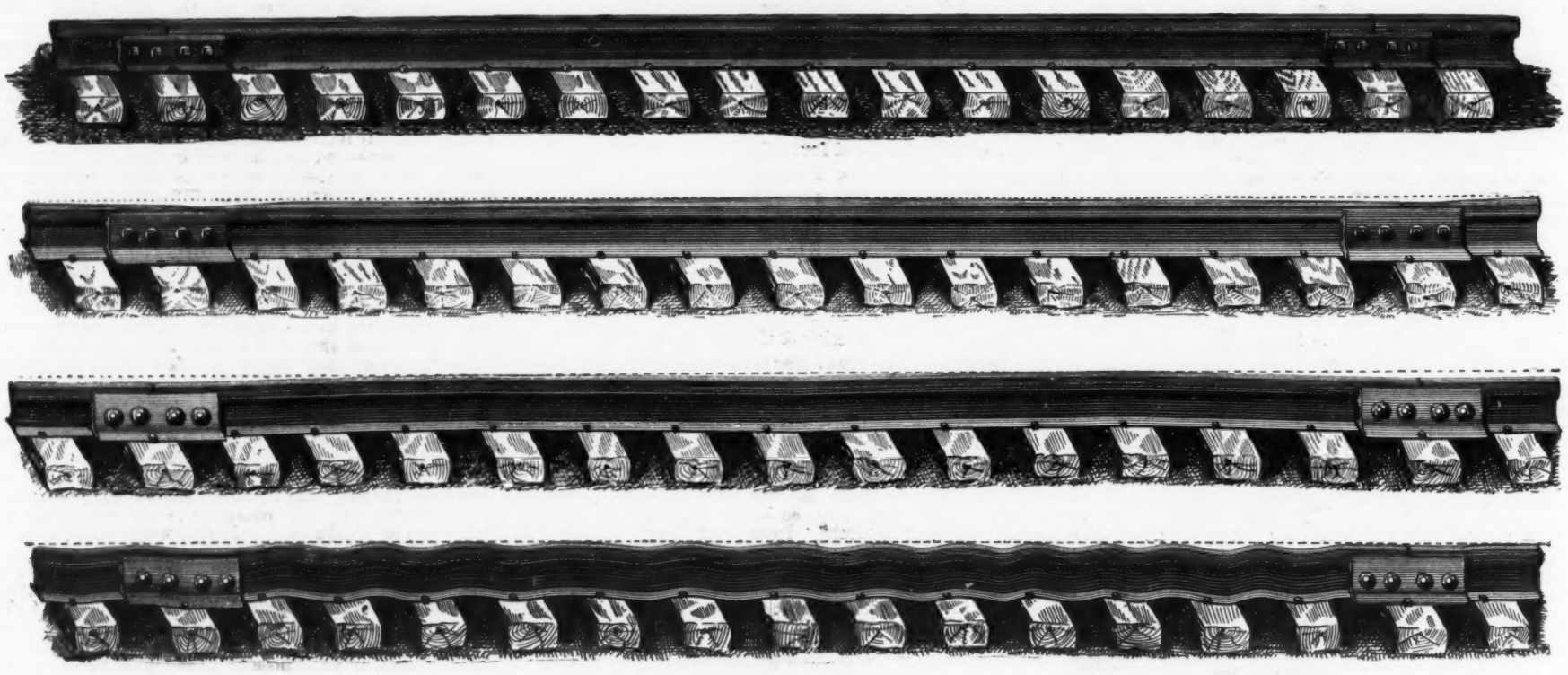
One gentleman spoke about the fast speed of the local passenger trains. The fastest speed usually found on trains is in the local passenger service, for 5 to 20 seconds—especially those stopping every two or three miles. They often attain a speed for a few seconds as high as 55 or 60 miles per hour. Then they shut off steam and apply the brakes, to stop the train. The heavy trains of eight to ten cars, running long distances, rarely attain 60 miles an hour—that is, on the ordinary schedules.

The greatest improvement that has been made in decreasing train resistance is in the improvement of the track by bringing up the standard of excellence and adoption of heavier and stiffer rails. I have been making a number of heavy rail sections for different railroads, and instead of making them simply heavy I have made them very stiff, which has reduced the deflection or wave motion under each of the wheels. Comparing the resistance of the Chicago Limited Express on stiff eighty pound rails with that of sixty-five pound rails which have been on the track some time, it makes a difference of 75 to 100 h. p. per mile. I have just made some ninety-five pound rails for a road which will be very much stiffer than the eighty pound rails. We find now that the condition in which they are keeping the line is so perfect that there is scarcely any oscillation on the best roads, and there is very little difference in the oscillation now in riding on a tangent or a curve. I should prefer a tangent for smooth riding, although the wheels press against the rails on curves. Unless they are properly elevated, there will be some oscillation, though our present trains move very steadily on the best tracks. I have made careful experiments, and with a track in good condition the heavy cars ride very steadily, leaving little to be desired.

Mr. Crosby: I should like to say now, knowing that Dr. Dudley is here, that what I learned from him, very kindly given in conversation when I visited his very interesting dynagraph car, was more than I learned in any other way, and I think when Mr. Dudley shall have the time to publish the data that he has on hand we shall know more about track construction and track resistance than is known anywhere else in this country, and I fancy in the world to-day. Of course I do not know all the data, but he has an enormous amount, and I am looking forward with very great interest to the time when he will give it to the world in published form; and it is very gratifying to me to find the facts that he has just stated of the very great difference in power required, due to difference in tracks; and I was not very much more than quoting him when I said that half the battle was in the track construction, so far as the power required was concerned.

Mr. C. O. Mailloux: I can endorse the remarks just made by Mr. Crosby. I myself had the pleasure and the honor of visiting Dr. Dudley's dynagraph car some years ago. I likewise felt that Dr. Dudley had it in his power to confer upon the railroad fraternity countless boons and favors. I said to some friends that if we could only get Dr. Dudley to run his car on a street railway track we could get from it revelations which I believe words would be inadequate to express.

I think that there are a great many things which are so good in Mr. Crosby's paper that it would be very difficult to select any of them for comment and reference. As for criticism I do not believe we could well undertake it unless we had been with him through the long, tedious course of experimenting, and the still more tedious course of calculation, designing, etc. Anybody who has been in the



FIGS. 1, 2, 3 AND 4.—EFFECTS OF TRAFFIC ON ROAD-BEDS OF DIFFERENT CONSTRUCTION.

business—and I see there are several such here—knows what a task and a series of problems the development of electric traction is. But while I cannot dwell upon all the good things, I think that there is one particularly good thing in Mr. Crosby's paper, which is the statement that the track is half the battle. Mr. Crosby is, I think, very modest. If I had made the statement myself I would have said the track is nearly the whole of the battle. I remember hearing our past-president, Mr. Franklin L. Pope, whom we have the honor to have with us this evening, telling me in a very sententious way that the street railway people seem to feel perfectly satisfied not only to have grades of seven or eight per cent., etc., but to have one at the end of each rail. My experience has been that on many roads they are not even satisfied with that, but they have one between every pair of ties or several in each rail Now, in the matter of designing electrical street cars particularly, we have to contend with all those difficulties, and we have to resort to theoretical reasoning, oftentimes, for want of practical data. That is the reason why I prayed within my inner consciousness that some man like Dr. Dudley might come before us and give us facts and data on which to base calculations. I found at the outset, as my colleagues doubtless did, that there was absolutely nothing to guide one or to base any calculations upon. I was therefore compelled, as doubtless they were, to make some crude preliminary experiments out of which I might have data, which, though far from conclusive or satisfactory, were yet far better than none. Now I found this—which I state simply in the hope to draw out the experience of others—that the ordinary data in relation to the traction on street railroads are entirely out of the way, entirely unreliable. Various estimates have been given by civil engineers and others for the electrical traction per ton for a street car. The most authentic figures, if my memory serves me right, placed the traction at something like 13 pounds per ton. In practice, as the result of the crude traction dynamometer experiments just mentioned, I have found the traction below 20 pounds with a car having a considerable weight. I have found that the traction per ton reached in some cases over 30 pounds, and it has gone as high as 40 pounds. Calculating the traction theoretically, using the coefficient of friction on the axle, the weight, and the well-known formula (since the power exerted is expended practically in overcoming the friction of the axles), one would expect to find a much lower traction. As a matter of fact, calculation gives a figure which is nearly in accordance with the data given by the engineers; yet practice always gives a higher figure by 50 per cent. and often more. I could not account for it unless it be that owing to the poor condition of the tramway rail surface, as the result of dirt, dust, depressions, etc., we have a greater amount, and a greater amplitude of rise and fall of the car as it rides over the minute excrescences on the track. I concluded from this that as the car is being continually and repeatedly lifted slightly we must introduce into the formula for traction a factor which is a function of the weight of the car itself; in other words, that the traction per ton increases with the weight of the car. I mean that the traction per ton for a car weighing three tons might be 20 to 25 pounds, while that of a car weighing seven or eight tons under the same circumstances might be probably 30 or 35 pounds. This view might explain the lower figures found for the traction of horse cars, these being of so much smaller weight.

I would like to ask Mr. Crosby in regard to the initial torque; that is, the amount of traction which is necessary to overcome static friction; in other words, what he finds the difference between static and kinetic friction to be. I have found in my experience that the initial traction went up as high as 80 to 100 pounds per ton. I would be very much interested in having the results of Mr. Crosby on these matters, because I think it is a subject on which we are all groping for much needed light. We are still working in comparative obscurity. Consequently any slight illumination will be very acceptable, not only to myself, but to all interested in the development of an art which is only in its infancy.

Mr. GEO. B. PRESCOTT, JR.: I can confirm to a certain extent what Mr. Mailloux has said about the unreliability of the traction figures for street cars that are given in some text books. Several years ago I had occasion to try a number of experiments with a storage battery car for the Sprague company, and in the interest of the West End Railway Company of Boston. It was very soon found from the actual power expended that the traction factor did not agree with the figures given in the text books. In order, if possible, to determine the value of this factor under ordinary conditions of level track, we secured a pair of powerful horses from the street railway company that were specially trained to start very gently and pull steadily. We took the car out on a nearly level track, and, with an ordinary spring balance attached between the car and the horses, endeavored by leaning over the dashboard to read the indications of the balance. (Laughter.) This was found to be practically impossible, owing to the rapid fluctuations of the indicator. Then followed a very amusing incident. Several gentlemen had been invited to ride in the car and witness the experiments At this stage a rope was procured and the guests invited to act as motive power, much to the amusement of the street urchins, who unmercifully guyed the gentlemen in silk hats and top-coats who were acting as car horses. A number of interesting readings were secured, which seemed to indicate that the condition of the track was not at all uniform, and it seemed to happen that when we were going to start the car it would always be blocked by a spike. As this meant raising the whole weight of the car in starting, it was frequently impossible for the men who were pulling the car to get it over the spike, and we would have to push it back and get up momentum; which probably goes to show that the traction coefficient is a function of speed. (Laughter.) These experiments were continued the whole afternoon, and on a perfect level we found the traction to be somewhere in the neighborhood of 30 pounds to the ton for a car weighing about six tons.

Dr. WM. E. GEYER: I must ask a question which will subject me to the criticism of being an electrical heretic. It has been stated over and over again this evening that in the case of electric locomotion the main battle is the track. Now, if the same attention were paid to the track, I would like to ask Dr. Dudley, or any other railroad man, what in their opinion would be the possibilities with ordinary steam locomotion, if we are willing to spend large sums of money on the track and on maintenance, approximately, as proposed by Mr. Crosby.

Dr. P. H. DUDLEY: I do not know how to answer the gentleman. Our experiments are not sufficiently carried out to determine yet all those points. About the best results are those that I have given you, that is a reduction of nearly 100 h. p. per mile compared with the ordinary 65 pound rail. I have designed some 105 pound rails which are nearly 100 per cent. stiffer than the 80 pound rails. We will probably save on the fast express trains nearly 200 hundred h. p. per mile, as compared with worn 60 or 65 pound rails. We have not rolled such a large rail yet; but it will not be long, probably, before that will be done. All trials show a very material reduction in train resistance with the heavy rails, as we increase the stiffness. I think it will be perfectly safe on a track of the 105 pound rails to run 120 miles an hour. I have ridden several times 75 miles an hour on heavy rails and did not feel it nearly so much as on the light rails when running 45 miles an hour. There is scarcely any oscillation. The track is in perfect line and the joints are all kept up. I might show you on the blackboard the shape of some of the rails we find in tracks. Taking a 30 foot rail on our best tracks; its surface to the eye would be represented by a straight line. (See Fig. 1.) The joint is well maintained in uniform surface with other portions of the rail. Take even 65 pound rails, after they have been run over a little while, if the joints are laid opposite, we find the rails in this form. (See Fig. 2.) Down at the joints and high in the centre. Now, of course, as the locomotive or train is passing over this depression, it further deflects and the wheels strike on the receiving end of the rail and cut out a piece from the head of the rail. This has been very common. Sometimes the effect is sufficient also to bend the rail down at this point. The apparatus I have on my car ejects paint on the rails where there is a certain deflection. In Fig. 2 it will be noticed the receiving ends of the rails are commencing to cut out. By ejecting the paint the trackmen have been able to surface the track so that on rails 15 or 16 years old they have not only checked the cutting out, but have brought up the surface of the rails to a much better condition, and they are nearly in a straight line at the present time. One serious trouble with many of the railroad people is that, while they want a heavy rail, they never consider the question of stiffness. I distribute my metal so as to make the section very stiff, not allowing so much in depth of the head of the rail as usually is done, but widening the head, because when these rails have been in the track a few years they become worn very unevenly, and must be removed from the track. I am making the heads on that account very much broader and the sections stiff, so the deflection of my 75 and 80 pound rail is less than one-tenth of an inch in the track. We mark all those rails for any deflection exceeding three thirty-seconds of an inch, under a load of six tons per wheel. That is about as close as the trackmen can work on a 65 pound rail. On an 80 pound rail they can work closer, but require great skill. The ejection of paint also shows where there is a rotten or loose tie. The form of rail where the joints are low, and high in the centre I call the first form. Then there is another form in which the joints and centre are low and high at the quarters, which I call the second form. (See Fig. 3.) Then there is another rail of which the surface is all full of waves. I call that the third form. (See Fig. 4.) A few years ago that was a very serious matter. We are often able to tell from the diagrams in the car what mill made the rails as we run over them. That feature has been materially improved by the mills. You will see at once, with trains running over rails of these various forms and with the deflections, there is a large amount of force lost. Rails high in the centre to the eye will be loose on the ties, so that there is quite a wave under each wheel. Even with very good track we find that under each wheel there is a depression depending on the weight on the wheel and speed of train.

Mr. LOCKWOOD: Before the discussion is concluded, I would like to call attention to just one point more which seems to have escaped attention so far, though I have no doubt that those of us who are experts in electric railroading have not overlooked it, and that is that with the increased use of electric locomotives we may expect to have better preserved tracks, and tracks which, moreover, will hold out much longer; because in the transfer of the rectilinear motion of the steam piston to its connecting rod and in its transformation to rotary motion in the wheels, there is a heavy pounding effect, which will certainly be absent from the motor which has a rotary motion at the outset.

Mr. FRANK J. SPRAGUE: I was not here early enough to hear Mr. Crosby's valuable paper, but I have gathered the gist of some of the points from the criticisms made. I wish to take the decided position that no automatic system of high speed service for either passengers, freight, or mail will ever come to a commercial issue. I will go further still: the moment you deny to a man the privilege of traveling 100 or 150 miles an hour you will have a flood of applications from people that want the opportunity. I know very well what Mr. Crosby's feelings are, and perhaps it was his belief in high speed service which brought him into the railway field, and I will relate an incident which will perhaps be new to you. I do not remember what year it was that Mr. Crosby left the army, but it was six years ago that I was married, and he was my groomsman. I saw him but one day, and a year or two later I happened to be in New York City at the time when the Richmond road was under consideration, and I was casting about for some one to associate with me in my work. It was just after some experiments on the elevated railroad had been carried through. Mr. Crosby flashed across my mind. He was then down in New Orleans. I said to my wife: "The time has come when I must have some one to help carry the load, and I want a man about my own age, and one who has nerve, and grit, and coolness, so that if he gets on the front of a car that is going 75 miles an hour, and there is danger ahead, he will stay there." I also said: "Do you think Mr. Crosby is that kind of a man? Has he that kind of nerve?" She replied: "I think he has." I went to the office, and telegraphed to him: "Can you come on to New York at once for a week?" He telegraphed: "Yes, I will come." He came on. We had a conversation, and the result was that Mr. Crosby resigned from the engineer's corps, and stands to-day as one of the foremost exponents of high speed service.

Mr. Crosby spoke of the possibility of returning the energy of the train to the line, and that it would have very little importance in dealing with the particular class of service of which he has spoken—high speed service over long distances. That is very true. I think perhaps the value there of a shunt machine, if used, would be on account of the constancy of the speed. That is, it would always be constant within a certain very small limit, especially with machines of the exceedingly high efficiency which would be used under those circumstances. That is where I think, perhaps, the shunt machines would be used. But on local rapid transit service, or service like that of the elevated railroads of New York City—which is not very rapid—but where we have stops every third of a mile, then the importance of returning energy to the line becomes at once very great, because from careful calculations I know it to be possible to return about 40 per cent. of the total energy used back to the line, and the facility with which this can be done increases very rapidly with the size of machine which is used. Where you can use shunt machines, and excite your field-magnets up to a very high saturation, and have a very reasonable latitude of variation, the criticism that was made that there would be a loss in energizing the field-magnets more than when in using series machines I do not think holds particularly good, for this reason: that the total energy used in the field-magnets forms a very small proportion of the total amount of energy used on the line, and if the return energy is 40 per cent. of the total, and the field energy of the magnet is only two or three per cent. of the total, the value of this method seems apparent.

The question of traction which has been so ably spoken of by Dr. Dudley has two entirely different bearings. If you are dealing with street car service, it is one thing. If you are dealing with high speed, clean rail service, it is an entirely different thing. I have found, so far as my practical experience goes, that the dirt on the track, the snow and mud, and the grades, were the questions that determined the power of the motors. When you consider that with 20 pounds traction per ton, the work on a one per cent. grade is equal to the work of traction, and that our street car service demands 12, 13 and even 14 per cent. grade work, the question of rail traction on a level amounts to very little in street car motor design, but it does amount to the greatest possible importance in high speed service.

Mr. Crosby was speaking, just as I came in, of the influence of currents on traction where the ground circuit is used. I was once a very zealous upholder, especially through our commercial agents, of the importance of using the ground circuit, because of the value of adhesion. My belief was founded on the experience I had with a very dirty track, for which the electricity was perhaps a sort of broom to brush away or a fire to consume the dirt. I am now of the opinion that the passage of the current, or at least so much current as is necessary for actual traction, has little actual influence on actual adhesion with clean rails. If it has any influence, it simply acts as a cleaner of the track—nothing more than that.

Mr. J. STANFORD BROWN: The question of grades has come up and been discussed, but the question of curvature has not, unless it was taken up before I came in. I would like to inquire what limitations would be put upon that in this very high speed service.

Mr. CROSBY: In the paper as read there is a calculation for the limit of curvature as a question of safety. Now there is a very important question as to the effect of curvature in increasing the friction coefficient. On that I have been able to do nothing more than take the text-book formulæ, and I am not at all sure that they are all right. The matter of safety I have discussed in the paper. The power I have assumed ordinary coefficients for. As to the values of the coefficients in street railway work on straight track I found with a dynamometer on an ordinary flat rail about 25 pounds average per ton for a car weighing about 12,000 pounds—that is, a street car, on an average street car track. As to the starting effect, I started a car equipped with the ordinary Sprague motor with 14 ampères by having a water resistance external to the car. Of course all cars as they are made by all the companies that I know of take a larger current than that to begin with under any conditions, simply because C is equal to E divided by R. You have so much R and so much E and you will have so much C. But that current is many times larger than is necessary to start a car. Those 14 ampères started a car on what was practically a level, rusty track, then I put a dynamometer in to check it, and as I remember now got about 175 pounds as the effort, applied gradually through a rope and a dynamometer to the starting of this car. That would be about 35 pounds—from 35 to 50 pounds per ton—and it checked exactly with the calculated torque resulting from the 14 ampères which were used electrically. In other words, I started once mechanically by men hauling on the dynamometer, and then electrically, and they checked very well, running somewhere to from 175 to 200 pounds for five tons.

Now, another gentleman has not I think been answered as to the question he raised respecting the feasibility of steam as compared with electric traction in case every possible improvement is made. I assumed in the paper I prepared previously on the subject that the traction coefficient would be the same for the same pull, no matter how exerted. It is so much per ton that has to be exerted. Now, the way I took hold was to calculate this very thoroughly—this cumulative load with steam, the coal necessary to be carried, and the water and the surface opposed to the atmosphere in increasing your speed, and I formed a table which I believe is reliable showing that at varying ratios for efficiency for electric locomotive machinery, and assuming what we know to be the average efficiency of the steam mechanism at such and such speeds, that you will have an economy greater in the one case or the other, and it runs this way, that if you can get 90 per cent. efficiency out of your electric service and have a frequent service—that is, of course, an indefinite term, but I define in my calculation a particular frequency which is not excessive as compared with the local traffic, say, of the New York Central Road—with such a frequency with 90 per cent. efficiency and at 20 miles an hour the electrical propulsion is slightly more economical than steam propulsion. Now, as you increase your speed the relative value of the electrical propulsion increases enormously, and finally at high speed, say 120 miles, your electrical propulsion is something like six times more economical than steam propulsion, considering steam propulsion even possible. But it is not possible to propel ordinary trains by steam at 120 miles for any length of line worthy of consideration, because the amount of coal and water that you are required to carry has reached a quantity that would require two or three tenders to take care of. You can see readily that it is a cumulative thing. Every pound of coal you put in requires some more coal to be burnt to pull that pound and you have to carry it, and you have water, so that when you get to the high speeds it is out of the question and we have nothing to look for at very high speeds, save electrical propulsion.

But if we come to comparatively low speed service and a comparatively infrequent service the steam will beat us.

Mr. PIERCE: Do I understand Mr. Crosby then to mean that for heavy freight service steam would be more economical than electricity.

Mr. CROSBY: Yes; I think heavy freight service, unless its frequency is far beyond anything we have to-day, can be carried on more economically by steam than by electricity. The table I prepared I calculated with a great deal of care for the cost of generating so much power in the one method and in the other, and I also introduced as nearly as I could the dead weights needed for producing that power by the two agents. Those I will say are factors that have to go into it; the cost of producing 1 h. p. hour and the number of tons of paying freight that 1 h. p. hour can haul when that horse power hour is expended by the one means and the other. Those two things being considered, put them together in the equation and you have at once the speeds at which the one or the other agent becomes more economical.

Mr. SPRAGUE: I heartily agree with Mr. Crosby in his opinion regarding the freight service—that it will for a long time be more economically carried on by steam than by electricity; likewise long trunk transportation. You must understand that electric transmission is going to bring up a new system of train operation and train despatching.

I think that in justice to Mr. Crosby I should explain why he was said to "have nerve." It was related that at a balloon ascension in the city of New Orleans, Mr. Crosby got away in the balloon without the operator because he was bound to go. I feel, in discussing this subject, very much as that operator probably did. Mr. Crosby on this question of rapid transit has run away from me, simply because I know of it only through the discussion that is going on.

Mr. THOMPSON: If I understand Dr. Geyer's question it was: "All other things being equal, why can we not safely use as high speed with the locomotive as with the electric motor?" There seems to be one certainty in favor of the electric motor as regards the matter of safety not found in the case of the locomotive. High speed means more danger of the numerous parts, such as connecting rods of the locomotive breaking; it means more danger of boilers exploding, etc. Where the armature is mounted on the car axle, as proposed by the speaker, the electric motor has no extra moving parts over those found in an ordinary car—as against, I don't know how many moving parts in the locomotive, —but a greater number intricately involved; so that an electric train would have a very high per cent. of safety over the steam locomotive, whether the present track is improved or not.

Preparations in Montreal for the Midsummer Convention.

A recent issue of the Montreal *Gazette* says of the preparations for the coming convention:

"No steps have yet been officially taken to prepare a civic reception for our coming visitors, but the Mayor and aldermen who have been seen upon the subject have expressed their willingness to do all that was necessary to give them a hearty welcome to the commercial metropolis of Canada, and no doubt when the proper time comes the city will do its duty. Mr. Corriveau has, however, completed arrangements by which the Victoria Rink will be the scene of an electrical exhibition, to last for three days or a week, and to include the latest devices in electrical art. The convention proper will be held in the Windsor Hall, and will be attended by delegates representing a capital of $200,000,000. The date is not decided, but it will be some time in the middle of August. One of the features of the visit will be a grand banquet to be given in the dining-room of the Windsor Hotel, which will be the Canadian headquarters of the association, and special attention will be paid to electric lighting as part of the decorations. A ball is also proposed, to take place in the Windsor Hall, and although the mere mention of a ball in mid-August seems sufficient to make it a failure in advance, yet the idea of the committee to have the room perfectly ventilated by electric motor fans will serve to insure its success from the standpoint of comfort. Manager Swett has already begun his preparations for the reception of the electricians, whom he intends to make so well satisfied that they will come back again to Montreal."

National Electric Light Association.

At a recent meeting of the executive committee, Mr. Allen R. Foote requested that his resignation as secretary and treasurer be accepted to enable him to devote more time to work in connection with the electrical department of the United States census and his economic studies. He reported $1,294.54 in bank and not one dollar of unpaid claims against it. Mr. Foote's resignation was accepted, to take effect April 1, 1891. President Huntley nominated Mr John W. Beane, of Brooklyn, as secretary and treasurer, and the nomination was confirmed.

Tuesday, Wednesday and Thursday, Aug. 25, 26 and 27, 1891, were fixed as the dates of the next convention, to be held at Montreal, Canada. The headquarters of the Association will be at the Windsor Hotel. It is probable that arrangements will be made for a very large electrical exhibit, to be open for the entire week. The following committees were appointed:

Committee on Amendments to the Constitution: Geo. B. Shaw, chairman; Marsden J. Perry, Hon. E. A. Armstrong.

Committee on Underground Conduits and Conductors: M. J. Francisco, chairman; T. Carpenter Smith, A. M. Robertson, John A. Seely, M. D. Law.

Committee on Finance: John A. Seely, chairman; E. F. Peck, H. H. Fairbanks.

Committee on Transportation: Mr. Edgar, Montreal, chairman; C. O. Baker, C. A. Brown, Henry D. Stanley, A. J. Corriveau.

Mr. John W. Beane, the new secretary of the National Electric Light Association, was educated at the United States Naval Academy and graduated in 1873. He then entered active service and served as an officer in the navy six years. He then resigned to enter business in civil life. In 1885 he became identified with the *Electrical Review* as one of its editorial staff. Later he accepted the agency of the Mather Electric Company for the Middle States. When the Tucker Electrical Construction Company was organized Mr. Beane became interested in it and was elected its general manager in 1888. In the winter of 1889-90 he visited Florida to enjoy a well-earned rest. On his return he accepted a special commission from the United Edison Manufacturing Company, in connection with its business in New England, and this was but recently terminated. He is well and favorably known to many prominent in electrical circles. He takes up his work with the good wishes of all who enjoy his personal acquaintance, or who are identified with the best interests of the association.

An Accident in New York City.

Were one to be led by the tenor of most of the newspaper accounts of fatalities from "electric wires" he would be forced to believe that at no time has the victim been guilty of any carelessness or indiscretion, that the laws of electricity are "subtle" in the extreme, making it impossible for any one to have anything to do with a thing electrical without the greatest risk. Almost enough has been said of the sentimentalism of the newspaper-reading public and of the sensationalism of the press, but it is still true that in most cases where some one falls victim to a shock of electricity the fault lies in his own carelessness.

However, it sometimes happens that an injury to the dynamo or motor, causing a defect which cannot be readily seen, will be at the bottom of one of the above fatalities, and again it happens that after the defect is known—at which time the machine should be shut down and thoroughly examined—the parties will continue to run the dynamo or motor, and when some one perfectly well aware of such defect, by reason of his carelessness in not taking precautions, is killed, the case is resolved into two parts—the defect in the dynamo is to blame and the victim is to be blamed for his own negligence.

Such a case was the fatality of last week in the silver-plating works of Messrs. Melville & Strong, at No. 3 East Fourteenth street, in this city. Until the morning of that day not the slightest trouble was given by the motor (a Baxter 6 h. p. on an arc circuit), when Mr. Elder, of the company, who had charge of the motor, and one of the employés, received a violent shock in the following manner: Mr. Elder, standing upon the *sheet-iron covered floor* at the pulley end of the motor and holding in his hand a nickel plated steel indicator, was about to take the revolutions of the machine. The other man, standing upon a wooden box, was screwing up the belt tightener, and the hand lever on the screw being missing, he used as a lever a long steel file without a handle. Mr. Elder touched his companion upon the hand with the speed indicator, and both men received a terrific shock. They agreed that the belt was tight enough, and that the revolutions were right, and seemed to see nothing more serious than a joke upon themselves. At all events the machine was kept running, though Mr. Elder took great care to warn all the employés to keep away from the motor. That evening, after the shutters had been closed, preparatory to closing the shop, the motor was still running, and one of the clerks, a boy of 18, was asked to remove some articles from the plating solution, at the same time being distinctly forbidden to turn off the motor current, as he had occasionally done before upon the closing of the shop.

Possibly the boy misunderstood the orders in regard to the motor, or felt that they were unnecessary. At all events he went to the pulley end of the motor, where the main switch is placed, to turn off the current. It was very dark, and in order that he might see where the switch handle was the boy lighted a match, and was about to reach for the switch handle when the match went out. "Oh! I know where it is," he said, thrusting in his hand, and by this movement his forehead, which just came level with the shaft, was brought in contact with the pulley flange, and he received a shock through his brain along the path running from his head against the pulley to his feet on the sheet-iron floor. It is not known whether the boy's soles were damp with plating solution, but instant death was the result of the contact.

An Electrical Trumpet.

An efficient trumpet of the simplest possible construction has been brought out by M. Zigang, of France. The principle embodies a ferrotype iron diaphragm clamped firmly around its periphery between two brass rings, carrying in its centre a bar armature, and a small electromagnet placed over the bar armature on the diaphragm inside the horn funnel. The horn funnel, which is of the ordinary foghorn shape, is secured to a brass frame, which carries the two binding-posts, and which has three lugs, by means of which the trumpet can be fastened to a sounding-board or box. The vibrations of the diaphragm are caused by the continuous making and breaking of the circuit after the manner of an electric bell. A regulating screw underneath bears against a platinum contact point upon the diaphragm near the outer edge, and as the magnet pulls the diaphragm the circuit is broken. A high rate of vibration is thus obtained, and a clear, shrill sound is emitted.

The "Trompette Zigang" is made in various sizes from a small sounder, No. 1, which might be used in place of an electric bell, up to a fog horn, size No. 7, which, when given full power, is enough to raise the dead! A few cells of battery will furnish the necessary power for even the larger sizes of these trumpets.

The "Trompette Zigang" is sold in this country by Messrs. Alexander, Barney & Chapin.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

Financial Standing of Electric Light Securities.—A prominent capitalist recently made the remark to the writer that he could borrow on gas stocks to the extent of 70 per cent. of their value, and they averaged about eight per cent. in dividends, but in electric stocks which averaged him 16 per cent. he could only borrow 40 per cent. of their value. This remark upon its face looks rather discouraging, but on reflection it has a brighter side. All new securities have to go through the same tests, and banks having no special facilities for examination of the securities lend as little as possible on them, so as to be on the safe side. It is important to be able to borrow money on securities, but generally speaking, those securities on which money is easiest bo wed pay the smallest dividends. For instance, government bonds which sell at high premium and pay very small dividends are considered the surest investments. When greater risk is entailed larger dividends are naturally expected. Electric light securities, so far as the banks are concerned, are going through a sort of probation and time will place them on a higher basis and the ability to borrow money on them will be increased. In the early history of the business many electric bonds were bought which brought disappointment and loss to the purchaser, but in the present condition of the industry persons who make proper investigation run no more risk in electrical investments than in many standard securities which cost a good deal more money. A few years will see electrical bonds with a set value, and the prospect of purchasing at any such figure as they are now marketed for will be very remote.

Western Union.—The directors of this company have declared the regular quarterly dividend of 1¼ per cent., payable April 15. The books close March 20, and open April 1. The report of the auditor for the quarter ending March 31 each year, partly estimated, is as follows:

	1891.	1890.	1889.	1888.
Net revenue	$1,500,000	$1,550,000	$1,350,000	$1,250,000
Interest and sinking fund	243,458	234,955	208,569	142,652
Balance	1,256,542	1,315,045	1,141,431	1,107,348
Dividend	1,077,400	1,077,391	1,077,376	1,077,357
Surplus	179,142	237,654	64,055	29,991
Total surplus	11,321,137	9,594,956	8,383,908	7,423,710

Commercial Cable.—This stock receives its regular quarterly dividend of 1¾ per cent., payable April 1 to stockholders of record March 21.

Thomson-Houston has had its usual good market during the week.

Series C, Thomson-Houston Stock, receives a dividend of $2½ per share, payable March 18, to stockholders of record of March 14.

Bell Telephone.—This company has declared its regular dividend of $3 per share on its capital stock.

Westinghouse.—Some of the Boston papers still continue to say ugly things concerning the preferred stock and to hint at the inability of Mr. Westinghouse to place the stock mentioned. The position taken in the columns of this journal from the first has been that the Westinghouse company would come out of its difficulties satisfactorily. The opinion was based on a consideration of the large business of the company, the ability of Mr. Westinghouse, and the interests of the creditors themselves. There is no occasion so far for any change of opinion and we expect without doubt to see the preferred stock all taken in the next thirty days. Mr. Westinghouse states that his negotiations in the matter of the preferred shares have progressed to his entire satisfaction, and only a little more patience is asked of those interested. F. Z. M.

F. Z. Maguire & Co., electrical securities, 18 Wall street, send closing quotations of electric stocks Saturday, March 14, 1891, in New York, Boston and Washington as follows:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	80⅞	81
American Telegraph & Cable	100	14,000,000	79¾	81
Central and South American	100	5,000,000	....	....
Mexican	100	2,000,000	....	....
Commercial Cable Co	100	7,716,000	106	109
Postal Telegraph Cable	100	5,000,000	....	....
Edison General Electric Co	100	15,000,000	103	104
Consolidated Electric Light	100	1,922 400	....	....
" " deferred	100	2,496,500	....	....
Edison Electric Illuminating Co	100	2,567,800	....	....
United States Electric Light	100	1,500,000	....	....
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	43⅝	44
" " preferred	25	4,000,000	25¼	25⅛
" " Series C	10	400,000	....	....
" " Series D	10	120,000	6⅛	7
" International Co	100	1,000,000	210	225
Thomson Welding Co	100	1,000,000	....	....
" European Welding Co	100	1,000,000	55	65
Ft. Wayne Electric Co	25	4,000 000	12⅜	13
Westinghouse Electric Co	50	5,000,000	10⅞	11⅛
Telephone:				
American Bell	100	12,500,000	199	199½
Erie	100	4,800,000	47½	48
New England	100	10,304,600	50	51
Mexican	10	1,280,000	90c.	97½c.
Tropical American	10	400,000	60c.	....
Edison Phonograph Doll	10	1,000,000	....	1
WASHINGTON.				
Pennsylvania Telephone	50	750,000	25	....
Chesapeake & Potomac	100	2,650,000	57	65
American Graphophone	10	600,000	7	8
United States Electric Light (Washington)	100	300,000	184	190
Eckington and Soldiers' Home Electric Ry	50	352,000	56¼	56½
Georgetown and Tennallytown	50	200,000	59½	63¼

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$230@$245	Cumberland	$60@ $62
Central Union	57@ 58	Wisconsin	118@ 120
Michigan	85@ 86	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$98@$100	Chicago Edison	$140@$150

NEW INCORPORATIONS.

The Pacific Wheelless Electric Company has been formed at Aberdeen, Wash., with a capital stock of $100,000.

The Elgin Electric Company has been incorporated to manufacture and sell dynamos, motors, etc., with a capital stock of $10,000. The incorporators are: C. E. Jones, W. H. Wilcox and Frank D. Wilcox.

The Knoxville (Tenn.) Electric Light and Power Company last week received and placed in position another 50 arc light dynamo. This was made necessary by the steady increase in the company's business.

The Monterey Electric Light and Development Company has been incorporated with a capital stock of $250,000. The directors are: Edward Ingram, S. H. Smith, David R. Dodwick, E. M. Carver and F. R. Day.

The Denver Highlands (Col.) Electric Company, with the object in view of furnishing electricity and appliances to towns and cities, has been chartered. The incorporators are: H. S. McDowell, R. H. Porter and R. E. Clark, and the capital stock is $500,000.

The Spokane University Heights Street Railway Company has been incorporated. Allan Garrett, Robert Abernethey and Leonard B. Cornell are the officers. The company is formed for the purpose of building, maintaining and operating a street railway in Spokane Falls, Wash. The capital stock is $100,000 divided into 1 000 shares at $100 per share.

The Cottage City (Mass.) Street Railway Company has been incorporated. The capital stock is $15,000. The directors are W. H. Phillips, of Taunton; W. C. Van Derlif, of Boston; Charles B. Dennis, E. G. Eldridge, A. G. Wesley, Hamilton J. Greene and John L. Mayhew, of Cottage City. E. G. Eldridge is president and H. J. Greene treasurer. The road is one and a half miles long.

The Adams Electric Company, which is incorporated under the laws of Illinois, with a capital of $5,000,000, has perfected its organization by the election of J. W. Slaughter as president and H. S. Pritchett secretary and treasurer. This company proposes to enter suit against all street railroad companies infringing the Adams patents. The first suit will probably be brought in Boston, against the Sprague Company.

AFFAIRS OF THE COMPANIES.

Ionia, Mich.—The annual meeting of the Ionia Electric Company was held last week. Directors L. B. Townsend, H. R. Wagar, J. E. Just, C. J. Rumsey and A. S. Wright were re-elected, and the directors re-elected President Townsend, Vice-President Wagar, and Secretary and Treasurer Just.

The Patchogue (N. Y.) Electric Light Co. held a meeting of stockholders in the office of Mr. Jesse C. Mills last week, and the following Board of Directors was elected: John S. Havens, Jesse C. Mills, Andrew Fishel, George D. Gerard, John H. Mills, Fremont Hammond, Edwin Bailey, Nathaniel O. Sweezey, Hallett J. Bishop, Henry Gillette and Isaac G. Willetts. The officers were elected for the ensuing year as follows; President, J. S. Havens; Vice-President, J. C. Mills; Secretary, N. O. Sweezey; Treasurer, J. H. Mills; Executive Committee, H. J. Bishop, G. D. Gerard and J. C. Mills. The principal topic of discussion during the meeting was the replacing of the arc dynamo with a 650 light incandescent dynamo. The present 500 light incandescent is not sufficient for the storekeepers. The stockholders were shown plans and specifications by representatives of the Westinghouse and Thomson-Houston companies and the matter was laid over for further consideration.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, March 16, 1891.

A. A. Griffin Iron Company has removed from 12 Cortlandt street to 106 Liberty street, New York.

The Hine Eliminator Company has removed from 49 Cortlandt street to 106 Liberty street, New York.

Messrs. Hawthorn & Co., New York agents of the celebrated Shipman Engine Company, have removed from 12 Cortlandt street to 114 Liberty street.

Dr. C. F. Chandler gave a lecture last week at Columbia College entitled "Storage Battery Cells." The Doctor is not an advocate of the electrical accumulator.

James G. Bedder, of Messrs. Queen & Co., Philadelphia, was in New York this week. Mr. Bedder advises all interested to send for catalogue I-66, electrical test instruments.

Mr. H. E. Duncan, of the American Waltham Watch Company, returned a few days since from his Mexican trip and called on several of his old friends in New York last week.

E. W. Hickox, for several years past purchasing agent for the New York Steam Company, has been appointed New York agent for the Buckeye Electric Company, with offices at 120 Liberty street.

Mr. Lea S. Robinson, of the Ryland-Robinson Company, of San Francisco, Cal., is on a business trip through the East. Mr. Robinson reports great activity in the electrical field along the Pacific slope.

The Joseph Dixon Crucible Company, of Jersey City, N. J., will begin April 1 the erection of a new and handsome office building, three stories high, on a newly purchased lot, 100 × 25 feet. The present offices will be used for factory purposes together with a new addition 100 × 100 feet, four stories high.

Mr. A. Livingston Bogart, of the well-known firm of A. L. Bogart, sailed on Thursday, March 12, for the Bermudas. Mr. Bogart has attended strictly to business for several years, and a rest is an absolute necessity. He has taken along his bicycle, and will no doubt astonish the natives. Every one wishes him a pleasant trip.

Mr. Wm. P. Hall, president of the Hall Railway Signal Company, which has made such rapid strides into popular favor during the last year, left for Florida last week. Mr. Hall has had a slight attack of pneumonia, and as he has never allowed himself many days' rest from his business, this is a doubly needed vacation. Mrs. Hall, child and maid accompanied him.

The annual election of the New York Telegraph Club was held last week at its rooms, 32 Cortlandt street. The following officers were elected for the ensuing year: President, E. E. Brannin (re-elected); First Vice-President, Richard Kane (re-elected); Second-Vice-President, Thomas J. Dunn; Third Vice-President, James I. Buxton; Recording Secretary, J. Clayton Watts; Financial Secretary, John R. Powers; Treasurer, John Brant; Librarian, L. E. C. Moore.

Mr. Samuel H. Taylor, the first agent of the Thomson-Houston Company on the Pacific Coast, and one of the best known electrical men in California, has become interested in the California Electrical Works, the oldest electrical supply house on the Coast. Mr. Taylor is at present in the East, looking after novelties. While with the Thomson-Houston Company Mr. Taylor always secured a little more than his share of business, and we can safely predict that his entrance into the supply business will make things lively on the Coast.

American Institute of Electrical Engineers.—The 55th meeting of the Institute will be held on Tuesday evening, March 17, at 8 o'clock, at the rooms of the Institute, No. 12 West Thirty-first street, near Fifth avenue. A paper will be read by Mr. J. J. Carty, of New York City, on "Inductive Disturbances in Telephone Circuits." The discussion will be opened by Mr. A. E. Kennelly. Members who are especially interested in the subject may be supplied with advance copies upon application to the secretary. The Council will meet in the secretary's office at 5 P. M.

Messrs. C. R. Truax, for several years with the American Bell Telephone Company, and afterward assistant general manager of the Accumulator Company of New York, and Mr. W. A. Vail, formerly superintendent of the Metropolitan Telegraph and Telephone Company, and later vice-president and general manager of the Boston Heating Company—which position he still holds—have formed a copartnership under the firm name of Truax & Vail, and have opened offices at 44 Broadway, where they will be prepared to supply electrical accumulators, "Edco" dynamos, motors and switches, and Walker electric meters, for which they have the agency for New York and vicinity, together with supplies of all kinds. Messrs. Truax & Vail will also do general construction work.

New York Subways.—Mayor Grant and Commissioner Hess, in view of the fact that the poles and wires must come down in the district between Third and Eighth avenues and Eighth and Fifty-ninth streets, by June 1, have instructed the Subway Company to build subways in the following streets: Irving place, from Fourteenth to Twentieth street; Sixth avenue, from Carmine to Fourteenth street; Seventh avenue, from Fourteenth to Forty second street; University place, from Eighth to Fourteenth street; Eighth street and Clinton place, from Third to Sixth avenue, and the four sides of Gramercy Park for electric light subways, and Twelfth street, from Second to Eleventh avenue; Forty-second street, from Third to Madison avenue, and Forty-ninth street, from Lexington avenue to Depew place, for telephone and telegraph subways.

L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, March 14, 1891.

The Thomson-Houston Company, on account of the strike in the Corning Glass Works, was obliged to shut down the incandescent lamp department for a few days.

Tests of Dynamos.—Some very interesting experiments are now being made at the Malden Electric Company's station by a class from the Massachusetts Institute of Technology in testing dynamos, engines, lamps, etc.

Lieut. Cahoon, of the Thomson-Houston Electric Company, gave an interesting lecture one evening last week before the members of the Harvard Electric Club. His subject was "Slow-Speed Railway Motors," and was illustrated by lantern views.

The Russell Arc Lamp Company has been receiving many orders during the past month for its new lamp, which it has been unable to fill on account of lack of manufacturing facilities. This will be obviated, and the company expects to be able to fill all orders after April 1.

A Complimentary Dinner was given to suburban superintendents by the American Telephone and Telegraph Company at the Quincy House a few days since, and between 20 and 25 guests were present. C. F. Hovey, New England manager of the company, did the honors of the occasion.

Mr. C. E. Bibber, formerly with the Holtzer-Cabot Electric Company, has been appointed general manager of the Consolidated Electric Manufacturing Company. The many friends of Mr. Bibber will be pleased to know of his well-deserved promotion. Mr. C. F. Armington succeeds Mr. Bibber with the Holtzer-Cabot Company, and is well known, having been connected with the firm for some time.

Good Effect of Reciprocity Treaty.—Eastern supply companies anticipate a boom in South America and Mexico trade as soon as the new reciprocity treaty goes into effect. There seems to be a general feeling of confidence in the future in all branches of the business, and this theory would seem to be supported by the inquiries and orders for future delivery that are being daily received.

The Second Worcester (Mass.) Electrical and Industrial Exhibition, now in progress, opens up very auspiciously and reflects great credit on its originator, Mr. H. H. Bigelow, who has always been identified with all that relates to progress in electrical matters. Prominent among the exhibitors of electrical supplies and machinery are the following: The Washburn and Moen Manufacturing Company, Worcester, wire; Franklin Electrical Company, Boston, motors; O. S. Platt, Bridgeport, switches; Frank Wheeler, Meriden, trolleys; Thomson Electric Welding Company, Boston, welding; Shultz Belting Company, Boston, belting; Pierce Brothers & Company, Leominster, electric railway supplies; Eureka Electric Light Company, New York, lighting; Standard Electrical Company, of Vermont, Boston, supplies; Edison Electric Light Company, New York, supplies; Brush Electric Store Fixture Company, New York, fixtures; Kilbourne Electric Company, Greenfield, electric engineering supplies; E. H. Hammond, Worcester, electric letter box; J. D. Sisson, Worcester, overflow stop; C. H. Paige, Worcester, electrical supplies; Waters & Culver, Worcester, electrical supplies; J. S. Avery, Worcester, anti-friction bearings; G. W. Barnes, Worcester, supplies; E. J. LeLand, Worcester, supplies; Worcester Oil Works, Worcester, oils; Chas. E. Green, Worcester, supplies; H. W. Willard & Co., Worcester, supplies; A. A. Kent, Worcester, boat power. Others are arriving daily, and it is expected that by the close of this week there will be a very full exhibit. The exhibition holds open until April 1.

C. A. B.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 CITY TRUST BUILDING, PHILADELPHIA, March 14 1891.

The Heisler System of long-distance incandescent lighting has just been introduced in the towns of Marine City, Mich., Belleview and Wauseon, O.

Mr. W. Irwin Cheyney, of 306 Builder's Exchange, has recently installed in this city and vicinity eight "Billberg" motors to be used in operating elevators.

The Blocklay Almshouse, at Thirty-fourth and Pine streets, is to have an electric light plant of 152 lights. The Quaker City Electric Company was the lowest bidder.

Mr. H. S. Cooper has resigned from the position of superintendent of the Conshohocken (Pa.) Electric Light Company to accept the general management of the Twin City Construction Company of Winston, N. C.

Messrs. Thos. H. Dallett & Co, manufacturers of the "Billberg" electric motors and dynamos, have removed from Thirteenth and Buttonwood streets into a new factory recently erected by them at York street and Sedgley avenue.

The Quaker City Electric Company has the contract for installing a 200-light plant in the Delaware Sugar House at the corner of Reed and Swanson streets, and an arc light plant for the Mount Penn Stove Works at Reading, Pa.

Mr. G. H. Fisher, manager for Messrs. Chas. A. Schieren & Co., says the demand for their perforated electric belts is steadily increasing. Within a few days this company has equipped the following plants with its belting: Altoona Electric Passenger Railway Company, the Lock Haven Electric Light and Power Company, the Philipsburgh Electric Light and Heating Company, and the plant in the Warden Apartment House.

Reading, Pa.—The Equitable Engineering and Construction Company of Philadelphia gave an exhibition recently of a new "Rae" electric car equipment on the East Reading Electric Railway. The car is built on the style of a Pullman parlor car, by the J. G. Brill Company, and is one of the handsomest cars ever sent from these shops. There were quite a number of invited guests on the car: Mr. B. F. Owen, president, and Mr. John A. Rigg, superintendent of the Citizens' Passenger Railway Company; Mr. Henry Aherns, president of the Reading Southwestern Railway; Mr. Morton McIlvain and Paul D. Millholland, of the Neversink Mountain Railway; Mr. A. J. Brumbach, president of the East Reading Electric Railway; Mr. John A. Printz and Mr. J. Esterley, directors of the same road. The car was in charge of Mr. Frank Talbot, of the Detroit Electrical Works, Detroit, Mich., who built the "Rae" motors. The trial was in every way satisfactory and ran without a hitch, making better time and using less current than any car that the East Reading Company has had. The principal features of the "Rae" system are the employment of a single motor instead of two, and the ease of riding and freedom from noise in the operation of these cars.

W. F. H.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, March 14, 1891.

Mr. Frederick Sargent has been appointed consulting electrical engineer in the construction department of the World's Exposition.

Mr. H. M. Underwood has been appointed general western agent for the Interior Conduit and Insulation Company, with headquarters at 1,105 Owings Building, Chicago.

The Riverside Park Street Railway, at Sioux City, Ia., will begin the erection of overhead electric work as soon as the weather will permit. This road will be equipped with the new Westinghouse low speed motor.

Mr. C. T. Gage, agent of the Heisler Electric Company for Michigan, combined business and pleasure in a visit to Chicago one day last week. Mr. Gage has just taken a contract for a 500-light equipment to be installed at Marine City, Mich.

Interior Conduits.—The first building to be completely equipped with interior electrical conduits is the "Dunshee" apartment building, now being erected in one of the most fashionable portions of this city. It is to be wired for 410 lights, the wire being the standard twin conductor, manufactured by the Interior Conduit and Insulation Company, of New York. It is intended that this installation shall be as elaborate and complete as it is possible to make it.

Linemen Quit Work.—The linemen of the Municipal Light and Power Company, of St. Louis, Mo., about 30 in number, went out on strike last week, and at present the result is not known. The cause of the action is a change in the wage scale which recently went into effect. The men have been receiving $2.30 per day and overtime. The company claims that there were many times when the men were idle for several hours during the day and that no reduction has ever been made for such idleness. The new scale offered them was $2.30 per day and overtime, but no pay for all time not engaged in work. This the men refused to accept.

Three-Cent Fares for Chicago.—Certain committees of the city council are wrestling with the new resolution, providing for a three-cent fare on all street railway lines in the city, which was introduced into the council some time ago. Two propositions were brought up and explained; one for graduated fares, based upon the distance traveled, and the other for a reduction, upon the basis of 33 tickets for $1 and a cash fare of five cents, distance not being considered. The first proposal was speedily discarded as being impracticable, and after an extended discussion the corporation counsel of the city was ordered to prepare an ordinance embodying the 33 rides for a dollar feature to be reported to the committee later on.

Lake County (Ind.) Electric Roads.—h ave been granted by the local authorities in East Chicago to the Hammond, East Chicago & Whiting Street Railroad to lay tracks from North Hammond through East Chicago to Whiting, with branch lines. The portion of the line between Whiting and East Chicago, four miles in length, will be constructed first, and the remaining portion, about two miles in length, to Hammond afterward. A single track will be laid at first. The motive power is to be electricity, supplied by storage batteries, since the ordinance does not permit the overhead system. The company, which has been incorporated in Indiana, has a capital stock of $250,000, and is said to be composed chiefly of Boston men, Edwin Reed, of that city, being president. The ordinance calls for the operation of the line between Whiting and East Chicago by next fall.

H. C. E.

ENGLISH NOTES.

LONDON, March 4, 1891.

London-Paris Telephone Wire.—A omewhat curious hitch is said to have occurred in connection with the telephone wire between London and Paris. It was proposed that the wire should terminate at either end in the Stock Exchanges, but brokers on either side of the Channel have, it is said, formally notified the governments concerned that in the event of the telephones being installed in the Exchange, they would like their use suspended during Stock Exchange hours. The brokers argue that as only one set of apparatus would be at the disposal of the public at either end, it would be easy for any given financier to manipulate the telephonic communication between the two Exchanges by sending a number of clerks to occupy the *cabine* one after another, and by this means prevent information being dispatched or received at the right moment. I can hardly believe but that the actual experience of the working of the line will soon dispel the prejudice of the stockbrokers at either end of the line.

Mutual Telephone Company.—On the last day o February the National Telephone Company was confronted with first formidable rival to which the expiry of the Bell pate ha given birth, by the opening of the first exchange in Manchester by the Mutual Telephone Company. This company hopes to successfully rival the National Company by the adoption of low rates (£5 to £6), metallic circuits and improved switching arrangements. The system now adopted at Manchester is the Mann system, and the transmitter employed is an improved type of Bell instrument manufactured by Messrs. Siemens Brothers & Co., who also have made an improved type of receiver. On the expiry of the Edison patent in July, the Mutual Telephone Company promises its subscribers a transmitter of greater sensitiveness. Mr. Bennett, the Mutual Company s general manager, states that his company has no less than 2,000 lines on order in Manchester alone, and that they have been extremely successful in obtaining way-leaves.

Transformer Distribution.—The lengthy paper upon "Transformer Distribution" which was read by Mr. Swinburne before the Institution of Electrical Engineers on Feb. 10 gave rise on Thursday evening last, as is generally the case with that gentleman's papers, to an extremely lively discussion. The paper itself was lengthy and covered far too much ground for the many subjects alluded to to be properly dealt with. The author, however,

succeeded in exciting a host of opponents. The paper opened with the statement that the distribution of electrical power by means of the alternate current transformer could hardly be considered to have reached its final state, and there was little doubt that present practice would be largely superseded. The future method foreshadowed by the author was that of transformer sub-stations feeding into low tension mains—a system which in this country is now coming rapidly to the front. Mr. Swinburne, as your readers perhaps recollect, is a sturdy opponent of what he calls the orthodox theory of parallel running of alternators, first propounded in 1884 by Dr. John Hopkinson, who assigned all the observed phenomena to self-induction. Mr. Swinburne has a theory of his own on the subject, which he calls the "armature reaction theory," which hypothesis seems to be a distinction without a difference. Mr. Swinburne then advocated the use of 1,000 volts pressure instead of the 2,000 volts and higher pressures in vogue in this country, being of opinion that by using higher pressures the increased cost of insulation was enormous, while the decreased cost of copper was not very great. He also advocated the running of low-tension alternators in parallel on to omnibus wires, from which the various circuits were tapped through "step up" transformers. It is needless to say that he did not fail to point out the advantages from the point of view of all-day efficiency of open circuit transformers. The hitherto published efficiencies of closed circuit transformers have, he said, only been possible on the supposition that they contained phenomenal iron. He then touched upon the use of condensers on a commercial scale, a matter in which he has had considerable experience. The most satisfactory kind of dielectric is, he states, a kind of paper called "butter skin," soaked in paraffine oil. In the discussion that followed Mr. Esson pointed out that in connection with Mr. Swinburne's armature reaction theory Dr. Hopkinson included armature reactions in his term of induction, and that while Mr. Swinburne objected to the assumption that the harmonic law holds good, he gave no idea as to how the armature reactions were to be estimated, nor any indication of a law that *did* hold good. Mr. Mordey then gave results of some important tests which he had just made, which, together with some made at the same time by Prof. Ayrton, led to the conclusion that the loss by hysteresis decreased as the load increased. Mr. Crompton said the Hedgehog transformer had proved to be a very satisfactory apparatus, but he gave figures from everyday experience which showed that the average load throughout the year was something like $\frac{1}{8}$ of the maximum, and that under these conditions the efficiency was not more than 50 per cent. Transformers, he said, were not so easy to manage as was imagined, and were not much better than secondary batteries in that respect. Mr. Evershed suggested that once you began to dispense with some of the iron it would be as well to go "the whole hog." He had recently worked out the data of a 10 h. p. transformer on this plan and found that at a frequency of 70 it would require two tons of copper. If, however, the frequency be raised to 20, the weight of copper was 200 pounds. Such a transformer was cheaper to make and there was no ever-present loss from hysteresis. The difficult lay, however, in making all alternators to give such a high frequency. The discussion will be renewed on March 12.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Motor Efficiencies.—Will you kindly tell me what is the usual efficiency for a shunt wound electric motor? H. D. K.

The electrical efficiency of motors from 3 to 15 h. p. varies between 85 and 95 per cent. See "The Electric Motor, and Its Applications," and Kapp's "Transmission of Power," both of which books can be furnished through this office.

Gray's Teleautograph.—I wish to learn the details of Gray's system of telegraphically transmitting messages by which the message received is a fac-simile of the chirography of the sender. Are any of the instruments of this system yet on the market? J. E.

We would refer you to the patent specifications (Nos. 386,814-5) of Elisha Gray's teleautograph for a full explanation of the system and instrument. The patent specifications can be furnished by the Patent Office, at Washington, D. C., or by The Electrical World Patent Bureau. We do not know of any installation of the teleautograph system as yet except experimental.

Measurement of Heavy Currents.—Kindly inform me through your valuable columns of the best method for measuring currents of about 3,000 ampères when only a Weston voltmeter reading to 150 volts and a Weston ammeter reading to 150 ampères are available. I know it can be done by the drop of potential method, but to make a standard resistance to carry such currents is not a simple matter. M. M.

The most practicable plan is the fall of potential method. You will have no special difficulty in making a standard resistance by taking a copper rod thick enough to carry the current without heating perceptibly while you are making your measurements and computing its resistance from its dimensions.

Charging of Condensers from Dynamos.—(1) Is it possible to construct a dynamo that will charge an electrical condenser approximately the same as from 1,000 to 10,000 cells of gravity battery? (2) Is there any such machine manufactured? A. G.

(1) Any dynamo will charge a condenser to a potential depending on the electromotive force of the machine. For instance, if a condenser is connected to a railway dynamo it will be charged to about the same potential as if 500 gravity batteries were employed. An Edison municipal dynamo charge will give the same charge as a 12,000 cell gravity battery and a large arc dynamo will give the equivalent of 2,000 or 3,000 cells. However, for all work where the potential of charge is not required to be known exactly a static machine is preferable.

Lamps Operated by Batteries.—Please give the following information through the correspondents' column: (1) Can I use eight or ten 20 volt 12 c. p. lamps on a circuit fed by 10 or 12 cells of two volt battery if I put the lamps in parallel circuit? (2) What, if any, difference is there in illumination between a 16 c. p. 20 volt lamp and a 16 c. p. 40 volt lamp? (3) Is the life of the battery in proportion to the number of lamps used, or is there an additional loss with more lamps? W. E. K.

(1) Yes, provided your cells are large enough to give the current required continuously. Probably you would require from 15 to 20 ampères, and few batteries have a low enough internal resistance to give such a current economically. (2) There should be none, although the 20 volt lamp having a shorter filament is not likely to give quite as good a distribution of the light. (3) The heavier current you take from your battery the more severe, of course, will be the loss from internal resistance.

Electrical Units and Magnetization of Iron.—Will you kindly answer the following questions: (1) When and by whom was the electrical equivalent of the commercial horse power determined, and what apparatus was employed? (2) What is the rule for calculating the number of magnetic lines carried by a magnet with a given magnetizing force? Please give an example and assume the data to be fixed? (3) What is the highest limit of magnetization for wrought iron? Constant Reader.

(1) The electrical horse power, properly speaking, was never determined at all in the sense you mean, because the electrical units are taken in terms of dynamical units, and hence are immediately applicable to any other dynamical unit. Read Dr. Kimball's articles on 'Electrical Units" in The Electrical World of Jan. 17 and 24, 1891. (2) The quantities involved in determining the magnetization of a magnet are: (*a*) the magnetizing force; (*b*) the length of the magnetic circuit; (*c*) its cross-section; (*d*) the permeability of the iron. The formulæ necessary and numerical data are given in great detail in Silvanus P. Thompson's "Lectures on the Electromagnet," which have recently been published in The Electrical World. For complete information you had better consult those papers. (3) Practically speaking, about 20,000 lines of force per square centimetre.

News of the Week.

THE TELEPHONE.

A New Telephone Building.—Ground has been purchased by the New York and New Jersey Telephone Company, at 158 and 160 Market street, Newark, N. J., for a new telephone building that is to cost $15,000. The plans for the building have been prepared by the same architect who designed the Telephone building in this city. The new building will be 48×150 feet, and six stories high. It will be built of brick, with stone trimmings. Only the fifth and sixth floors will be occupied by the telephone company. On the ground floor will be two stores, while the next three floors are to be divided into offices. It is expected that the building will be completed by Dec. 1. It is estimated that the company's lines in the State of New Jersey were damaged to the extent of $70,000 by the storm a month ago.

THE ELECTRIC LIGHT.

The Waukegan (Ill.) electric light plant will soon be completed.

The New Albany (Ind.) electric light station will soon be in operation.

The Merrill (Wis.) Electric Railway and Lighting Company has contracted to place 50 arc lights in that city.

The Baton Rouge Electric Light Company will not only repair the damage done to its plant by the late fire, but will spend $10,000 in improvements.

Watkins, N. Y.—The Steuben Electric Company has been making negotiations with the Watkins Board of Trade for a city electric light plant. The plant is to cost $12,500.

The Fairfort (N. Y.) Electric Light Company which was started a few weeks ago will be a success. Robert Wilkinson and others will take up the business and put in a plant at an early date.

The New Albany Light, Heat and Power Company will soon have completed its plant sufficiently to illuminate the stores in the business portion of the city with incandescent electric lights.

The Salem (Va.) Electric Company has been organized, and has installed a Thomson-Houston electric light and power plant. The company has a contract with the city of Salem for 50 arc lights, all night schedule, for five years. The plant will be in operation June 1.

A Welcome to Montreal.—The Montreal *Star*, in a recent issue, says editorially: "The National Electric Light Association of the United States is composed of the principal electricians and others interested in the development of the powers and uses of electricity. The association is national, and for the better advancement of science holds two conventions yearly, one in summer and the other in winter, when the members from all over the continent attend and exchange views and read valuable papers on subjects pertaining to electricity. It has been suggested that the summer convention for 1891 might with great pleasure and profit be held in Montreal. It is needless to say that the members of the association will be heartily welcomed by our citizens, and everything done to make their visit a pleasant one."

The Thomson-Houston Electric Company reports the recent sale of the following apparatus:—Arc dynamos: Ashland, O., 50 lights; Lowell, Mich., 50; Mansfield, Pa., 25; City of Chicago, Ill., 50; Elyria, O., 70; Louisville, Ky., 50; South Chicago, Ill., 150; Greenville, Mich., 60; Lincoln, Neb., 150; Newport, Ark., 50; Joliet, Ill., 150; Arkadelphia, Kan., 30; Medina, N. Y., 50; Olathe, Kan. 50; Parsons Kan., 35; Hyde Park, Ill., 50; Clinton, Mo., 50; Shelbyville, Mo., 50; Oshkosh, Wis., 50; Harrison, O., 35; Osage, Ia., 18; Farmville, Va., 30 Incandescent apparatus: Quincy, Ill., 1,300 lights; Monroe, Wis., 1,300; Moosic, Pa., 300; Morristown, Tenn., 650; White River Junction, Vt., 650; Arkadelphia, Kan., 650; Olathe, Kan., 650; Pella, Ia., 650; Waterville, Conn., 1,300; Charleston, W. Va., 1,300; Babylon, L. I., 650; Clinton, Mo., 500; Boston, Mass., 650; Chelsea, Mass., 1,300; Harrison, O., 650; Huntington, Ind., 650; Port Huron, Mich., 1,300; Tuscola, Ill., 500; Worcester, Mass., 1,950; Pawpaw, Mich., 300; Bennington, Vt., 1,300; Omaha, Neb., 1,300; New Albany, N. Y., 650; Greenville, Mich., 650; Virginia City, Nev., 650; Farmville, Va., 300; Mt. Vernon, N. Y., 1,300; West Superior, Wis., 1,300. Isolated plants—Arc apparatus: Schlitz Brewing Company, Chicago, Ill., 6 lights; Alger, Smith & Co., Black River, Mich., 30; J. P. Craig, Memphis, Mo., 30; Glenwood Company, Yonkers, N. Y., 9; Sanderson & Sons, New York, N. Y., 30; Central Iron Works, Harrisburg, Pa., 50; Bradner, Smith & Co., Chicago, Ill., 20; Woodcock & Loring, Chicago, Ill., 12; D. B. Fiske & Co., Chicago, Ill., 35. Isolated plants—Incandescent apparatus: Warden Apartment House, Philadelphia, Pa., 1,600 lights; Tuscaroras Advertising Company, Coshocton, O., 100; Backus Wire Nail Company, Cleveland, O., 400; Read House, Chattanooga, Tenn., 600; Hotel Oglethorpe, Brunswick, Ga., 150; Deloach Mill Manufacturing Company, Atlanta, Ga., 100; National Distilling Company, Milwaukee, Wis., 100; St. Louis Railway Company, St. Louis, Mo., 200; A. Zeese, Chicago, Ill., 100; Lane Bros., Newark, O., 150; C. E. Harwood, Lynn, Mass., 150; G. A. Robertson & Co., Hinsdale, N. H., 50; Brooks Bank Note and Lithographing Company, Boston, Mass., 100; Orr and Strettle, Piqua, O., 600; Piedmont Bath and Power Company, Oakland, Cal., 500; Fitchburg Manufacturing Company, Fitchburg, Mass., 200; Calumet Distilling Company, New Chicago, Ill., 450; H. C. F. Koch, New York, N. Y., 1,200; New York Jockey Club, New York, N. Y., 800; Liss & Rickerman, Chicago, Ill., 100; D. B. Fiske & Co., Chicago, Ill., 250; Walter Aiken, Franklin Falls, N. Y., 100; Clark's Hotel, Boston, Mass., 150; Monmouth Park Hotel, Little Silver Station, N. Y., 800; Wm. Ruehl Brewing Company, Chicago, Ill., 200; E. Richards & Son, Sandy Hill, N. Y. 100; Jordan & Stewart, Oldtown, Me., 50; Newmarket Manufacturing Company, Newmarket, N. H., 400; E. P. Parksons & Co., Tilton, N. H., 200; American Scotch Iron Company, Syracuse, N. Y., 50; E. Frank Lewis, Lawrence, Mass., 100; American Tin and Lead Company, Cañon City, Col., 200; Fairchild Paper Company, E. Pepperill, Mass., 200; Gouverneur Wood Pulp Manufacturing Company, Gouverneur, N. Y., 50; Lockport Pulp Company, Lockport, N. Y., 200; North New York Marble Company, Gouverneur, N. Y., 50; Allen Bros. & Co., Sandy Hill, N. Y., 400; Walter M. Lowney, Boston, Mass., 200; Clarendon Hotel, Brooklyn, N. Y., 400.

THE ELECTRIC RAILWAY.

The Seattle (Wash.) Electric Railway Company will extend its line to Ballard, a distance of one mile.

Still Another Pittsburgh Electric Railway.—At McKeesport, Pa., local capitalists are organizing a company with the intention of constructing an electric street railway line between Christy Park and Riverton, two suburbs of that town. The distance between the two places is about four miles, and the railway, as proposed, would run through the heart of the city of McKeesport.

The Tenth Annual Meeting of the American Street Railway Association is to be held in the city of Pittsburgh, Pa., the third Wednesday in October (the 21st), 1891. Reports will be made upon the following list of subjects: "A Perfect Electric Motor," H. A. Everett, Cleveland, O.; "A Year's Progress of Cable Motive Power," J. C. Robinson, Los Angeles, Cal.; "Public and State Treatment of Corporations," G. Hilton Scribner, New York City; "The Dependent—Overhead or Underground—System of Electric Motive Power," Geo. W. Mansfield, Attleboro, Mass.; "The Independent—Storage or Primary Battery—System of Electric Motive Power," Knight Neftel, Lancaster, Pa.

The City & South London Railway.—"According to Mr. Stephen D. Field," says *The Electrician*, London, "a weak point in the London underground electric road is the placing of the armatures on the wheel axles of the locomotives." After quoting him as saying that "running at a speed of 20 miles an hour, the blow delivered on the wheel, axle and armature by passing over so much as a grain of sand is equivalent to the blow of a large steam trip hammer," *The Electrician* says: "In the absence of any proof of this remarkable statement, and of the presence of any sand in the tunnel, the direct driving of these locomotives is still to be regarded as one of the most important steps that has been made in electrical traction."

The Thomson-Houston Electric Company has just closed a contract for 40 additional cars with the Cincinnati Street Railway Company, of Cincinnati, O., and for six cars with the Pueblo City Railway Company, of Pueblo, Col. During the recent snowstorm in Denver, Col., it is said, there was not one cable line in operation, while the Thomson-Houston electric cars were operated without the slightest difficulty. The Denver Tramway Company has decided to abandon the Eighteenth street cable and use electricity as a means of car propulsion. The T.-H. Company has also closed contracts with the Rock Creek Railway, Washington, D. C., for 12 cars; Harrisburg City Passenger Railway, Harrisburg, Pa., for 14 cars; City Electric Railway, Little Rock, Ark., 28 cars; Jefferson Avenue Railway, St. Louis, Mo., for 25 cars; Oxford Lake Line, Anniston, Ala., 6 cars; Allentown & Bethlehem Rapid Transit Company, Allentown, Pa., 15 cars; Marquette City & Presque Isle Company, Marquette, Mich., 3 cars; Braddock & Turtle Creek Railway, Braddock, Pa., 3 cars; Salt Lake Rapid Transit Company, Salt Lake City, Utah, 3 cars; Buffalo Street Railway Company, Buffalo, N. Y., 12 cars; Pittsburgh & Birmingham, 2 cars (making the fourth Thomson-Houston electric railway in Pittsburgh, Pa.); Troy & Alpia Street Railway, Troy, N. Y., 20 cars; St. Louis & Suburban Street Railway Company, St. Louis, Mo., 45 cars; Chattanooga & North Side Railway, Chattanooga, Tenn., 4 cars.

PERSONALS.

Gen. E. S. Greeley, of E. S. Greeley & Co., is at Lakewood, the famous New Jersey health resort, with his family for a short stay.

Prof. Elisha Gray, of Highland Park, Ill., the well-known electrician and inventor, is registered at the Windsor Hotel, in this city.

Mr. M. L. Hellings, superintendent of the International Ocean Telegraph Company, has received from the Spanish Government two beautiful medals with the corresponding diplomas signed by the Queen Regent of Spain.

Mr. Stephen E. Barton, president of the Electric Mutual Insurance Company of Boston, was in New York last week. He is still laughing over his arrest down in Georgia for alleged violation of the laws of that state prohibiting the doing of insurance business without a license, and says he can't imagine why such a charge should have been made. His company did write a policy on the Atlanta Thomson-Houston station, but the business was transacted in Boston. The Sunday before his arrest he spent in Atlanta on his way to Florida to shoot, but he affirms that he did not even call upon any of the electric light men while in the city.

LEGAL NOTES.

Liability for Crossed Wires.—The wire of a telephone company had become impaired where it crossed an electric railway wire, and was in such a condition as to arrest the notice of a prudent man engaged in the business of either company. There was no guard wire over the electric wire. The fall of a burning building broke a telephone pole, which caused the telephone wire to break and fall across the railway wire; and, while in this condition, plaintiff's horse came in contact with the telephone wire, and was killed. Both companies were negligent, and liable for the value of the horse. (United Electric Railway Company v. Shelton, Supreme Court of Tennessee, 14 S. W. Rep., 863.)

Right of Way for Telegraph Company.—In a proceeding under Act Miss. March 16, 1886, to condemn a right of way for a telegraph and telephone company over a railroad right of way, witness for petitioners stated that the land to be occupied by the posts was worth from $2,50 to $3 per mile, while experts for defendant said it was worth to the telegraph company $100 per mile. The commissioners fixed the amount at $40 per mile. Since it did not appear that "the commissioners acted upon testimony that was irrelevant or incompetent, and that their award was contrary to law . . . and that injustice had been done," the award would not be disturbed. (Postal Telegraph Cable Co. v. Alabama & V. Ry. Co., Supreme Court of Mississippi, 8 South. Rep., 375.)

Injury by Telegraph Wire.—Where the employés of a telegraph or telephone company, in removing wires from poles along public highways, frighten the horse of a person lawfully using the highway by carelessly letting a wire fall upon the horse, the company is liable for the damage actually resulting from such careless-

ness, including injuries sustained by the driver from the running away of the horse. Testimony as to plaintiff's hearing, memory, temper, manner of doing business, his ability to labor and his health before and after the accident was properly admitted to show the nature and extent of the injury, the evidence being confined to facts within the observation of the witnesses. (Staring v. Western Union Telegraph Company, Supreme Court of New York, 11 N. Y. Supp., 817.)

Industrial and Trade Notes.

Messrs. Jos. C. Paulus & Co., of Philadelphia, received a large order from Aix-la-Chapelle, Germany, last week for Munson's leather belting.

The Brewster Trolley Wire Clamp, handled by the Electric Merchandise Company, is receiving general endorsement by street railway men.

Messrs. Taft Bros., of 44 Cedar street, New York, importers of pure rubber and gutta percha, are very busy, and report trade in the electrical field as increasing.

Messrs. H. & E. C. Baxter, of 18 Fulton street, Brooklyn, manufacturers of electrical specialties, have never been more busy than at the present time, and the outlook for the season of 1891 is very promising. Every one should have their new catalogue.

Messrs. Charles A. Schieren & Co., of New York City, have issued a neat pamphlet and price list of their celebrated perforated leather belting, which contains, besides many commendatory letters from various users throughout the country, many useful notes.

Mr. R. B. Pierpoint, 170 Washington street, Chicago, agent for Gould & Watson, of Boston, is showing a large line of samples of mica insulators of new design. This company has exceptional facilities for the production of insulators for special conditions.

The Nassau Electrical Company, manufacturers of the celebrated capsule battery, owing to large increase in business and the want of more room, has removed from 19 Park place to 112 White street, New York. This company will shortly bring out several new and novel specialties.

The Great Western Electric Supply Company reports very large sales of "K. K." and other wires, and has booked orders ahead for future delivery. This company has one of the largest supply houses in the United States, and every month does an enormous business in various branches.

The Lunkenheimer Brass Manufacturing Company, of Cincinnati, O., has issued a handsome typewritten circular to consumers announcing this company's purchase of the entire plant and good will of the Porteous Brass Manufacturing Company of the same city, and pointing out the advantages of the Lunkenheimer oil cups, etc.

Renehan Mast Arm.—The Great Western Electric Supply Company, with its usual enterprise, has secured the general agency for the "Renehan" mast arm. This is something entirely new, and is said to be one of the best mast arms on the market. The Great Western Company is negotiating with several large cities to equip the street light systems with it.

The Self-Winding Clock Company, of 26 Broadway, New York, pioneers in the electrical synchronous system of horology which is now universally used, is now prepared to rent the clocks for the reasonable amount of $1 a month. This is the acme of horology. For a small yearly sum we have always the "sun time," and without any trouble of winding.

The Hazelton Boiler Company, of New York City, manufacturers of the well known "Hazelton porcupine" boiler, have been doing a very brisk business during the past year in electric light station power plants. Among the most recent installations, for the Havana Gas and Electric Light Company, of Havana, Cuba, were four 150 h. p. Hazelton boilers.

Electric Motors Without Commutators is the title of a small pamphlet issued by the Electron Manufacturing Company, of 79-81 Washington street, Brooklyn, which shows that the carbon brushes of the Perret motor, of which this company is the manufacturer, render a machine as convenient and as easily managed as one without commutators or brushes.

The Electric Merchandise Company, through its well known secretary, Mr. A. H. Englund, recently closed a contract for all material necessary for the complete electrical equipment of the Riverside Park Street Railway at Sioux City, Ia. This order speaks well for the excellence of the material handled by this firm, as it was given in the face of the sharpest competition.

Cheap Aluminium.—The Pittsburgh Reduction Company now offers pure aluminium in any quantity for $1 a pound. This is the lowest price yet quoted upon this metal, and as it is nearly four times lighter than nickel or German silver, it will be a much cheaper metal to use than either of them, and is at such a price that it can be used economically for many purposes.

Mr. Charles M. Rumrill, the well-known electric railway supply dealer, of 109 Liberty street, New York, will hereafter, in addition to carrying on his other business, act as New York agent for the Gould & Watson specialties, including the molded mica insulators of this company. Mr. Rumrill has also secured the exclusive agency for the United States of the Bates Sand Distributor.

The Barriett Motor Company, of 10 Cedar street, New York has just shipped six 8 h. p. and two ¼ h. p. motors with generators to Brazil to be used in dental work. This company's business has so increased that more room is necessary, and another floor will at once be added to its present quarters. Mr. Barriett has so perfected his motor that he gets a high efficiency with very slow speed.

Mr. George H. Raymond, formerly president of the Raymond Furnace Company of Norwalk and New York, has become connected with the Detroit Heating and Lighting Company, with offices in the new store 114 Liberty street, New York. Mr. Raymond will look after the interests of the company in Western Connecticut, Massachusetts, Southeastern New York, and Northern New Jersey.

The Riker Electric Motor Company, of 45 and 47 York street, Brooklyn, N. Y., reports an unusually large business for the commencement of 1891. This company make a specialty of high class multipolar and bipolar dynamos and motors, the low speed and compact designs of which make them admirably adapted for direct acting machinery, such as ventilating fans, blowers, car propulsion, elevators, hoists, etc.

The Ansonia Brass and Copper Company, of Ansonia, Conn., New York City and Chicago, has issued its electrical price list for 1891—"No. 165." The "A B C" triple braid weatherproof line wire is advertised at a most reasonable price, which, combined with the well-known good qualities of this wire, render it one of the least expensive of the kind. Many other specialties are shown in this small catalogue.

The S. S. White Dental Manufacturing Company, of Chestnut street, corner 12th street, Philadelphia, has purchased the patent rights of the "Partz" battery cell and the "Partz" sulpho-chromic salt for battery cell use. The company has a large stock at Philadelphia, and is prepared to furnish large orders on short notice. The White Dental Manufacturing Company has at no time been but in the front with the best of goods.

The Great Western Electric Supply Company has recently reduced the price of the G. W. lamp. It has been thoroughly demonstrated that this is not a cheap lamp, by any means, and when compared with several standard lamps on the market it has shown up admirably. The Great Western has had a great sale for this lamp, and it has been necessary to about double its facilities. This is one of the first instances of a reduction in the price of a standard lamp.

The Jerome Kidder Manufacturing Company is in receipt of many very flattering testimonials with regard to the good results obtained by the use of its medical battery, among which are letters from L. Dowse, M. D., Petoskey Sanitarium, Petoskey, Mich.; W. H. Hoag, Amsterdam, N. Y., and J. H. Mosely, M. D., of Tomah, Wis, the tenor of all the letters being that the writers have all had a varied experience with medical batteries and find the Kidder one of the best.

The Eureka Electric Company.—One of the handsomest catalogues out for 1891 is that of the above company, sole agent of the Loomis system of arc and incandescent lighting. The catalogue is profusely illustrated with beautiful cuts of the different apparatus, including electrical supplies, etc., manufactured by the company. It also contains a partial list of plants installed, which amount to many thousands of lights. Many commendatory letters have been received by the Eureka Company.

Messrs. Meyrowitz Bros., of 295 Fourth avenue, New York, have just patented a new electric surgical motor of a capacity of ⅛ h. p. It is made in the shape of a sphere, and is highly finished and nickel plated, with all the mechanism perfectly protected and hidden from view. This motor is five inches in diameter and weighs only 6¾ pounds, complete with flexible shaft and hand piece. It can be suspended from a bracket, and swung in any position or placed upon a table, as may be desired by the operator.

The American Private Telephone Company, of 64 and 66 Broadway, New York, with its new telephone instrument, gives great promptness and reliability of service. Perfect articulation, simple construction, combined with skillful workmanship, besides their very low cost, make these instruments especially adapted to private line work where connection with distant buildings is desirable, or to situations where connection with different floors of buildings whose size precludes the use of speaking tubes is required.

The Electrical Supply Company, of Chicago, in speaking of the merits of "Shield" brand moisture-proof wire, usually offers, besides its own assurances of the merit of this wire, the statements of various authorities who have approved it. Prof. French, of Cincinnati, has the following to say of "Shield" brand, which he tested for the Board of Public Improvements in that city. "Sample No. 6 'Shield' brand wire, length 12 feet. The resistance, after soaking one hour and thirty minutes, is 10,000,000 ohms, same being approved for general use."

The Dayton Fan and Motor Company, Dayton, O., is placing on the market an improved type of ceiling fan, preparatory to the coming of warm weather. The company claims that the advantages possessed by this fan are the ease with which it can be stopped or started, and the ability to adjust the blades simultaneously without throwing off the belt, loosening a screw, or in any manner interfering with the power; thus practically giving absolute and complete control of each separate fan. This company manufactures a handsome line of ceiling fans, as well as column and counter fans.

The Mutual Electric Protective Association, of New York City, has removed from its executive office at 29 Murray street to a handsome and roomy suite of offices at 458 Broadway, where will be both the executive office and the main central station of this company's burglar alarm system. This company controls a most efficient protective system, which has been quite extensively introduced in New York City with satisfactory success. The "Mutual" system is the only one registering a patrolman on the premises of the place protected independent of the alarm, thus consisting really of two systems.

The New Process Raw Hide Company, of Syracuse, N. Y., has received the following commendatory letter from the Morgan Engineering Company, of Alliance, O.: "Your letter inquiring if the raw hide gears gave us satisfaction in regard to wear and noiseless feature, and the need of no oil, is received, and we would say that the eight pinions were used on four motors, two 15 and two 20 h. p., for operating two 35-ton cranes for handling locomotives for the Pennsylvania Railroad Company at Altoona, Pa., and that they have given us the highest satisfaction. We have replaced on a large 10-foot planer steel bevel wheels with raw hide gears, and they have now been running over a year and a half, giving entire satisfaction and outwearing both bronze and steel."

The Crocker-Wheeler Catalogue.—The new catalogue which the Crocker-Wheeler Electric Motor Company, New York, distributed at the late Providence Convention should be in the hands of all the electrical people who did not secure one on that occasion. It presents an attractive appearance, and the instructive and well-prepared matter within its covers is generously illustrated and worthy of careful perusal. The text describes very plainly the construction of the company's electric motors and their special features. It also gives some valuable data in the way of tables, stating horse power, dimensions, and cost of the various machines, with directions for setting up and running them. Considerable space is devoted to the smaller motors, 1-6, 1-8 and 1-12 h. p., and their numerous applications.

Messrs. Queen & Co.'s ammeters and voltmeters of the "magnetic vane" type are meeting with great favor for central station and isolated plant use. They are accurate—contain no permanent magnets, and may be left in circuit continuously. Special instruments for any current or E. M. F. are made to order by this well-known firm. The Edison General Electric Company, New York, says of these instruments: "They have given us excellent satisfaction, and it affords us pleasure to recommend these instruments." The New York and Pennsylvania Telephone and Telegraph Company, Elmira, N. Y., says: "The magnetic vane ammeter purchased of you is giving entire satisfaction. This ammeter is in daily use in our testing department, and has always been found reliable and accurate."

The Ongley Electric Register System.—The register system which has been put upon the market by the Ongley Electric Company, of No. 1 Broadway, this city, was quite fully described in a recent number of THE ELECTRICAL WORLD. A complete working plant of this system may be seen in operation in the factory of Mr. F. Kaldenberg, on East Thirty-third street, this city. A recent examination of it showed that it very fully meets all the requirements of actual service. The plant has in reality three separate and distinct functions to perform. The first of these is commonly performed by the watchman's clock system, the second function is that of a fire-alarm system, and the third is known as the stop-engine system. With a minimum number of wires it is possible for the watchman from any room in the building in which the plant is installed to send in and record the ordinary watchman's signal, to send in an alarm of fire, or, in case of accident to any of the machinery to stop the engine at once without an intermediate signal to the engineer. When the importance of this last feature of the system is more fully understood, and its value in the large machine shops is realized, the system is likely to find very extended use. In the plant above mentioned all the details of the installation have been carefully attended to, a duplicate set of batteries being provided, and the system is tested twice each day.

Arc Lights in Incandescent Circuits.—The question of the use of arc lamps on incandescent circuits has been a subject of discussion for central station owners and owners of isolated plants for some years. The first efforts in this line did not prove successful. One of the first lamps placed on the market in this country was the Simplex arc lamp, and many of these were in use up to one year ago, when the Electrical Construction and Supply Company brought out the "Ward" lamp for direct current. Since that time thousands of these lamps have been in use in central station and isolated work, and they have proved commercially successful. The largest number of these lamps in use on any one central station (the Edison station, Brooklyn) is between 600 and 700. The largest number in use on isolated plant work is 80 lamps, and many plants are furnished with from 30 to 60 of these lamps. In isolated plants the benefit of arc lamps, in connection with the incandescent plant, is obvious. Many large spaces can be better lighted with arc lamps run from the same plant than with incandescents, the light obtained, in proportion to the current used, being about as twelve to one in favor of the illuminating power of the arc lamps. There is, of course, a saving of the extra apparatus necessary to run a special arc plant, and, each pair of lamps being separate, they can be turned on or off, as the light is desired. Another point in their favor is their safety. In central station plants, even where series arc circuits are run in connection with the incandescent service, there are many points where it is very costly to run the arc service, but where the incandescent service is handy and arc lamps on the incandescent circuit can be readily attached. There also often arise cases where day service is in demand but not in sufficient quantity to run the series arc circuit. In these cases the incandescent service lasts through the entire twenty-four hours, and it is cheaper to run arc lamps from the incandescent circuit rather than to run the special series arc circuit. Many central stations are using these lamps, putting them out both on contract and on meter. The price obtained for the current, when on meter rates, is equivalent, or nearly so, to the price obtained for current when supplied to incandescent lamps. For inside store lighting, in connection with central station work, the use of arc lamps from incandescent circuits is of special interest to owners of direct current incandescent plants. The light from arc lamps on these circuits is clear, steady and perfectly quiet.

Hard Fibre.—Some years ago there was established in Wilmington, Del., a factory for the manufacture of a substance which is known to the electrical and mechanical world as hard fibre, or vulcanized fibre. It had been discovered that when certain vegetable fibres were subjected to a somewhat complicated and expensive chemical treatment they underwent a remarkable and not well understood change, their loose and fragile tissues became compact, hard and tough, forming a product which combines many of the qualities of wood and metal. It was indeed a remarkable discovery, and supplied the arts with a material that had long been sought for. There seemed to be a vast number of uses to which such a substance could be applied, and in this respect the hopes of its early producers have been more than realized. By slightly changing the treatment to which the vegetable tissues are subjected two distinct products may be obtained. One is flexible and much resembles a fine piece of sole leather, though much stronger and more durable. It may be cut or punched into any desired shape. The other is more like an exceedingly hard piece of wood or a soft metal, and may be sawed with a sharp saw, turned upon a lathe, drilled, planed or milled in the same way that metal is worked. It is exceedingly tough, cannot be broken, and will stand any amount of friction without showing signs of wear. At first the flexible kind was most largely produced and used for carriage washers, and washers in machinery where tight water joints were required or where there was friction to contend with. Another large field for its use was found in the dust guard trade and to-day the Pullman cars, the Pennsylvania Railroad and many other lines are thus equipped. The hard product was first employed for bearings for light running machinery It is coming largely into use now for making the best grade of trunks, for which purpose, owing to its lightness and great strength, it is admirably adapted. The greatest use, however, for hard fibre has sprung up during the past few years in electrical construction. It was discovered that when made in a certain way it was a most excellent non-conductor, equal to glass or hard rubber in that respect and capable of being used in a thousand places where anything fragile would not serve. Nearly every dynamo, every lamp and lamp socket, every switchboard and electric call bell has some of its parts made of hard fibre. The Delaware Hard Fibre Company has recently begun operations in a new and handsomely equipped factory in Wilmington Del, the home of this industry. The officers and directors of the company are men well known in manufacturing circles. Mr. Wm. H. Swift, the president, was for many years the president of the Diamond Match Company. Mr. Jos. Swift was a director in the same concern. Mr. Wm. G. Pennypacker is the barrel manufacturer of Philadelphia. Mr. Samuel Bancroft, Jr., is the head of the firm of Jos. Bancroft & Sons, cotton manufacturers of Wilmington. Mr. W. L. Beecher is the secretary of the Diamond Match Company. The treasurer and general manager is Mr. Chas. G. Rupert. The company owns all the patents of Mr. Robert P. Frist, who is the superintendent of its factory and controls the manufacture and sale of hard fibre rods, long tubes, insulating cleats, the process of swedging and a number of other products and processes that are of importance in the trade. The especial properties which are claimed for the product of the Delaware Hard Fibre Company are its high insulating qualities, great hardness and its compact, homogeneous texture, which are attained by the use of chemically pure materials, improved machinery and some radical changes in the old methods of treatment. Oil, which has been largely used to cheapen the process of manufacture, has been entirely excluded, and the result is that hard and uniform structure, combined with remarkable tenacity, which are properties much desired in electrical construction and in the machine shop generally. Their flexible fibre is treated with chemically pure glycerine, which makes washers and dust guards that are absolutely free from acids or any ingredients that would injure the metal with which they are brought in contact.

Business Notice.

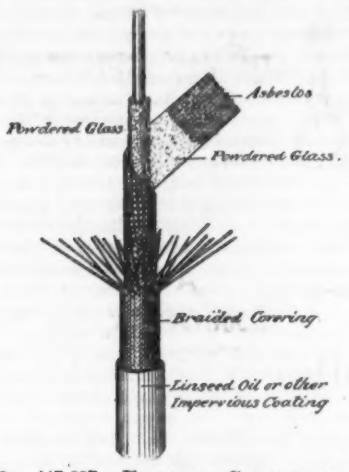
Battery Cut-out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren Street, Syracuse, N. Y.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENTS ISSUED MARCH 10, 1891.

447,553. Signal Box; Frederick W. Cole, of Newton, Mass. Application filed Dec. 23, 1890. In a signal box and signal wheel, combined with a switch for shunting out the said signal wheel and another switch for cutting out the said signal wheel, said switches being operated in succession to first shunt out and thereafter cut out the said signal wheel.

447,767. Electric Arc Lamp; Henry C. Forgason, of Oakland, Cal., Assignor of one-half to H. H. G. Comstock, of same place. Application filed May 23, 1890. In a double-carbon lamp, the combination, with main and auxiliary cut-outs, of a magnet in the main cut out circuit, a second magnet for operating the



No. 447,897.—Electric Conductor.

auxiliary cut-out, and a contact operated by the first mentioned magnet for energizing the second magnet, whereby the main cut-out may be cut out by the auxiliary. (See illustration.)

447,768. Combined Annunciator and Telephone System; John Chisholm Francis, of New York, N. Y., Assignor to Elias M. Greene, of same place. Application filed Nov. 5, 1889. A telephone instrument the coil of which is provided with a loop connected to spring terminals having a spring actuating hook normally closing the terminals and arranged to break the circuit at the terminals when supporting the telephone.

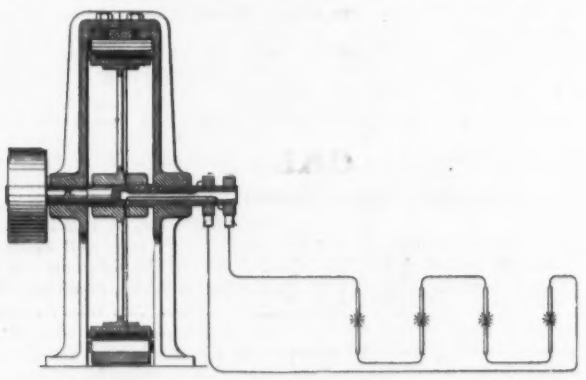
447,788. Electric Switch; Jno. M. Orford, of Bridgeport, and Jno. C. English, of New Haven, Conn. Application filed Dec. 19, 1890. The combination, in an electric switch, with the terminals, of a pair of pivoted circuit-breaking levers, a pair of guided plungers connected together for purposes of mutual operation, slotted links interposed one between one of said plungers and each of the circuit-closing levers and springs surrounding said links.

447,826. Electric Switch and Cut-Out; William Hochhausen, of Brooklyn, N. Y. Application filed March 12, 1889. The combination, with a spring-actuated switch of a catch and a releasing magnet, all inclosed in a suitable case, a releasing button having a cam adapted to engage with the edge of the catch and a resetting arm or lever connected with the switch.

447,827. Electric Starting Switch; William Hochhausen, of Brooklyn, N. Y. Application filed Nov. 26, 1889. The combination, with the main switch and its actuating devices, of a resistance switch positively operated by said actuating devices in a direction to throw out the resistance and having a lost motion adjusted so that an interval shall elapse after the closure of the main switch before the resistance switch may be moved by the actuating devices to position where the resistance will be thrown out.

447,832. Electric Light Fixture; Joseph Kintz, of Ballard Vale, Mass., Assignor of one-half to the Craighead & Kintz Co., of New York. Application filed May 15, 1890. In an electric fixture the combination of a main part or section provided with a nipple, a plug inserted in the back part of the nipple, electrodes fitted in said plug and projecting from the forward end of the plug, a secondary part or section made in the form of a tube, a plug fitting in the inner end of said secondary part and having a flange-like portion lapping over said end of the secondary part and a notch in said flange, a rib or tongue on the secondary part, entering the notch of the flange, electrodes in the last said plug and a coupling-piece connected with the one part and engaging with the other.

447,833. Coupling for Electric Wires; Climpson M. Knight and Thomas Hawken, of Salem, Mass. Application filed Nov. 20, 1890. In accordance with this invention the coupling is composed of two like halves or portions adapted to embrace the wire. The ends of the wire to be coupled are each provided with a bulbous portion. Each half of the coupling has two grooves or passages arranged in alignment to receive the wires, and recesses



No. 447,920.—Method of Operating Arc Lamps.

are formed at the terminations of each groove or passage for the bulbous portion or end of the wire.

447,857. Galvanic Apparatus for the Human Body; Percy G. Williams, of Brooklyn, N. Y. Application filed June 6, 1890. In a galvanic apparatus, the combination of a battery having a flat thin case on one side with felt or like material, a strap for fastening the battery to the body, a contact piece, a strap for fastening the contact piece to the body, and a flexible conductor extending between one of the elements of the battery and the contact piece.

447,858. Induction Preventive for Telephones; Thomas F. Wright and Ed. G. Wilson, of Chicago, Ill. Application filed July 28, 1890. An induction preventive for telephones, comprising a hollow casing having perforations and a coil, one end of which is embedded in a spool or block of wood or its equivalent and the other terminates opposite the centre of a perforation in the casing opposing the diaphragm of a telephone receiver, to which the casing is secured.

447,861. Conduit for Electric Wiring in Buildings; Sigmund Bergmann, of New York, N. Y. Application filed Aug. 1, 1890. The invention consists in a seat or seats placed at various points in conduits for electric wiring and constructed to receive a switch.

447,867. Electric Switch; Horace T. Clark, of Bridgeport, Conn. Application filed January 26, 1891. In an electric switch, the combination with a vertically movable circuit closer, of a pair of double faced actuators, a spring for forcing said actuators apart, a handle for moving them, and means of engagement between their operating-faces and the circuit closers.

447,885. Trolley Carriage and Conductor; Chas. J. Luce, of Niantic, Conn. Application filed April 4, 1890. In an electrical railway, the combination of a moving vehicle upon which a motor is carried, a main conducting-wire, a trolley carriage mounted upon the wire provided with a wheel or pulley above and below the wire, and a conductor attached to the rigid arm, and the latter pivoted to the carriages at a point between the wheels or pulleys and connected at its other end to the moving vehicle.

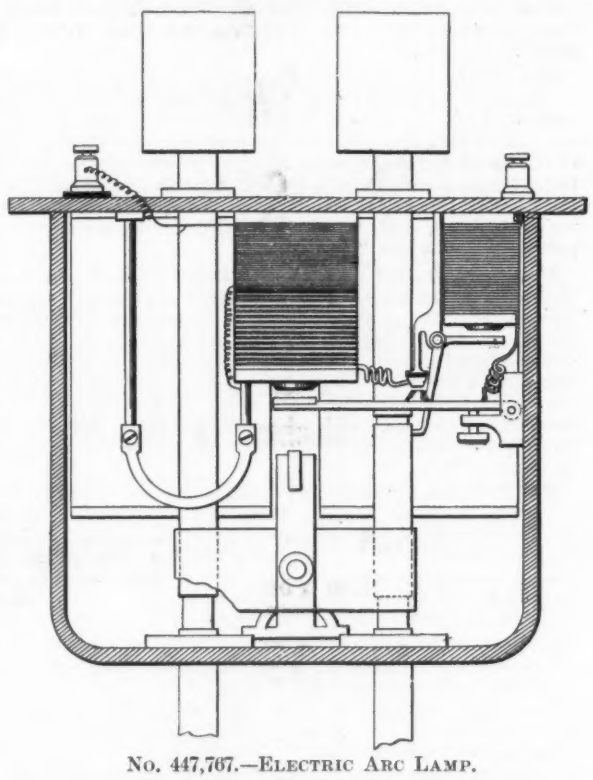
447,894. Electric Light Signal; Walter R. McCann and Simon S. Creider, of Sterling, Ill. Application filed Sept. 8, 1890. In an electric alarm signal, the combination, with the wires of a main circuit having a series of local alarm circuits controlled thereby, of means for operating and closing the main circuit, consisting of a rotary drum having a metallic band or tire, a covering of non-conducting substance covering the tire, except an annular space at one end, rows of metallic pins through the non-conducting substance in electrical contact with the tire, a metallic tongue in constant electrical contact with the uncovered portion of the tire and with one wire of the main circuit, a series of tongues or strips engaging with the rows of pins, respectively, and means for establishing electrical connection between any one of the series of tongues and the other line of the main circuit.

447,896. Insulation Electric Conductors; Frederic J. Nash, of Brooklyn, N. Y. Application filed May 12, 1890. An electric conductor insulated by a surrounding bed or layer of insulating material in the condition of an impalpable powder, whereby the particles thereof pack together so closely as to exclude air and moisture.

447,897. Electric Conductor; Fred. J. Nash, of Brooklyn, N. Y. Application filed May 13, 1890. According to this invention a layer of pulverized glass or other equivalent pulverized insulating material is applied around the wire, this layer being held against the wire by means of a retaining envelope. (See illustration.)

447,906. Electric Railway Signal; Wm. W. Rosenfield, of New York, N. Y., Assignor to the American Electric Railway Signal Company, of Jersey City, N. J. Application filed May 17, 1890. In a railway signal system, the combination, with the rails and an electro-magnet bridging an insulated joint therein, of a line-battery connected to both rails, and constructed to energize the magnet when the current is divided.

447,918. Automatic Telephone Exchange; Almon B. Strowger, of Kansas City, Mo. Application filed March 12, 1889. In a system of telephone, telegraph, or other electrical exchange, the combination with a series of wires leading to different stations in the system, and having their ends insulated and held in curved rows, of a contact needle supported at the axis of the rows, mechanism for moving the needle from row to row, mechan-



No. 447,767.—Electric Arc Lamp.

ism for moving the needle along the row, magnets for actuating said mechanisms and wires leading from a sub station for conducting electricity to energize the said magnets.

447,920. Method of Operating Arc Lamps; Nikola Tesla, of New York, N. Y. Application filed Oct. 1, 1890. The method of abating or rendering inaudible the sound emitted by arc lamps supplied with or operated by an alternating or pulsating current by increasing the rate of such alternations or pulsations up to that of the limit of audition. (See illustration.)

447,921. Alternating Electric Current Generator; Nikola Tesla, of New York. Application filed Nov. 15, 1890. The combination in an annular field of force formed by opposing polar faces with radial grooves or serrations and with said poles, of a connected series of radial conductors so disposed with relation to the serrations that while one portion of the radial conductors is passing between the strongest parts of the field, or the points where the two poles most nearly approach, the adjacent or intermediate conductors will pass through the weakest parts of the the field, or the points where the two poles are most remote. (See illustration.)

447,939. Electric Motor; Wm. H. Chapman, of Portland, Me., Assignor to the Great Electric Motor Company, of same place. Application filed July 5, 1890. In a multipolar motor, a series of field-magnet cores constructed and arranged in pairs, the two cores in each pair being placed parallel to the axis of revolution of the armature and connected together in one piece, but removed from contact with the cores of the next magnet and having their pole ends curved tangentially to a plane at right angles to the axis of revolution in both directions from the centre of the width of each of said cores.

447,943. Railway Car Telegraphy; Wm. S. Cook and Moses Chalmer Cook, of South Omaha, Neb. Application filed April 21, 1890. In an electric railway system, the combination of a line telegraph wire broken into insulated sections, normally closed circuit closers located at the breaks between the sections, a vehicle or train having a partial circuit extending there through-including telegraphing instruments, a front contact device electrically connected with the front end of said partial circuit and engaging said line conductor and carrying means to throw open said circuit-closers, and the rear contact device connected with the rear end of said partial circuit and engaging said conductors, and provided with means arranged to close the closers opened by the front contact.

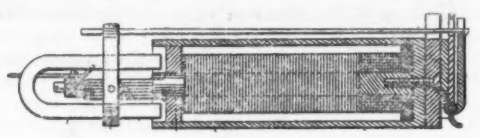
447,998. Electric Alarm; Geo. W. Adams, of Boston, Mass. Application filed June 6, 1890. In an electrical protective system, the simultaneous combination of two independent circuits, one open and one closed, with one and the same break-wheel, the revolution of which is adapted to simultaneously close the open circuit and break the closed circuit by means of an insulating trolley, a springing-arm, and contact-point for the open circuit, and a springing-arm for the closed circuit,

448,031. Electric Railway Signaling Apparatus; Eugene L. Harrison, of Crookton, Minn. Application filed March 4, 1890. In a railway signaling apparatus, a series of electromagnetic signals included within a branch circuit, in combination with a main circuit provided with opening and closing jaws located at intervals along the circuit and a moving object adapted to traverse in contiguous track and to actuate the jaws.

448,040. Commutator; William Hornberger, of Elkhart, Ind. Application filed Aug. 2, 1890. For a commutator, a section having a side edge protected or strengthened by a metal of greater density or hardness.

448,044. Combined Push and Pull; Albert Iske, of Lancaster, Pa., Assignor, by mesne assignments, to the Self-Acting Bell Company, of same place. Application filed June 27, 1890. In combination with a contact-plate forming one of the terminals of an electric circuit, a pull-knob constituting the other terminal thereof, and provided with an attachment for making electrical contact with said plate, a push-button which is in electrical communication with said pull-knob, and an attachment of said button arranged to be moved at will into contact with said plate, the circuit being open only when neither of such attachments is in such contact and closed equally well by a push or by a pull.

448,084. Electrode for Arc Lamps; Albert C. Seibold, of Mt. Vernon, N. Y. Application filed Dec. 24, 1890. An electric arc lamp, having a holder or casing for the positive carbon electrode, consisting of a metallic tube having an interior diameter freely admitting the carbon, the lower end of said tube being provided with a removable flat plate arranged in immediate



No. 448,169.—Polarized Annunciator.

proximity to the arc and having an opening of somewhat less diameter than the carbon.

448,107. Electric Arc Lamp; La Motte C. Atwood, of St. Louis, Mo., Assignor to the Atwood Electric Company, of same place. Application filed Oct. 28, 1890. An electric arc lamp having carbon-supporting rods, a motor, a train of gearing located between the motor and rods and containing an automatic clutch, by which the gearing is thrown into and out of action, a magnet and armature, a spring actuated pivoted lever connected to said clutch, a pivoted bell-crank lever, a link connecting said levers, and a link connecting said bell-crank lever to said armature.

448,110. Electric Door Opener; Louis Bates, of Jersey City, N. J. Application filed July 14, 1890. An electric door opener comprising a pivoted latch actuated by a spring and formed with a notched extension, a locking pawl actuated by a spring and formed with an arm or extension and electro-magnets, a vibratory armature provided with a hammer.

448,125. Train Order Annunciator; Leonard Tracy Crabtree, of Oconto, Assignor of one-half to Gilbert Milligan Knapp and Dayn Eldridge Wescott, both of Shawano, Wis. Application filed July 11, 1890. A train order annunciator having a battery and a telegraph receiving instrument and a train order recording and indicating device electrically connected to the battery and telegraph receiving instrument, and adapted to make and break circuit therewith by adjustment of its mechanism.

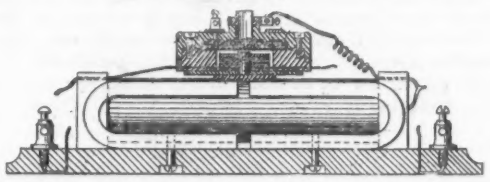
448,128. Body Battery and Attachments for the Same; John A. Crips and George F. Webb, of Jefferson, Ohio. Application filed Nov. 21, 1890. A battery-cell comprising a copper plate having notches in its ends, zinc plate bent upon itself and inclosing the same rivets passed through the two integral members of the zinc plate, and notches to hold copper plate in place, and absorbent material between the zinc and copper plates.

448,153. Apparatus for Intensifying Electrical Undulations; John C. Ludwig, of San Francisco, Assignor of seven-eighths to H. T. Compton, L. F. Monteagle, T. Paige and G. M. Roe, of same place; A. T. Ayres, and W. C. Mason, of Oakland, Cal., and H. J. Ayres, of Akron, O. Application filed Sept. 10, 1889. The invention consists of a combined receiving and transmitting instrument mounted between two induction coils, each of which contains a primary and secondary circuit. Each primary circuit is connected with a local battery, and the two primary circuits are connected with a single wire, which leads the current above the diaphragm of the receiving and transmitting instrument. The line-wire connects with the secondary circuit on each side and passes through the bobbin of the receiving and transmitting instrument below the diaphragm and thence to the ground. (See illustration.)

448,164. Device for Raising or Lowering Incandescent Electric Lamps; Chas. F. Reinmann, of Brooklyn, N. Y. Application filed Feb. 8, 1890. A ceiling plate having binding posts for the line wires, hangers dependent therefrom, spring brushes dependent from said ceiling plate and in connection with the binding posts, a shaft journaled in said hangers, a spring motor for rotating said shaft, an automatic locking and releasing device also in connection with said shaft, a spool fixed to said shaft and having conductive heads from each other and in contact with said spring brushes, and a lamp cord composed of insulated conducting wires, the upper ends of which are connected respectively to the spool's heads.

448,166. Automatic Switch-Board and Safety Cut-Out for Electric Circuits; Edgar A. Sweet, of Milford, Mass., Assignor of one-half to Joseph L. Buxton, of same place. Application filed Oct. 22, 1890. An automatic switch-board and safety cut-out consisting of an electromagnet, an armature and a toothed arm connected to each other, an armature operative spring, a wheel adapted to engage said toothed wheel and provided with arms, a bevel gear, a handle and a spring, the latter to turn the shift axially.

448,167. Switch for Incandescent Lamp Sockets; Alfred T. Tregurtha, of Everett, Assignor of one-half to John A. Murray, of Boston, Mass. Application filed Sept. 20, 1890. The invention consists of a plate having a contact point or electrode,



No. 448,153.—Apparatus for Intensifying Electrical Undulations.

and a casing secured to and between two insulating plates or heads, in which casing said plate is arranged to move up and down, the sides of the casing forming a guide or bearings for the plate in its movements therein, and a spring arranged to bear upon said plate, and a bar or key pivoted in a suitable support and adapted to engage with said plate.

448,169. Polarized Annunciator; Ernest P. Warner, of Chicago, Ill. Application filed Jan. 9, 1890. The invention comprises an electromagnet having an annular space between the poles thereof and a pivoted permanent magnet having its poles in said annular space, whereby said permanent magnet is vibrated by changes in the direction of the current. (See illustration.)

448,172. Trolley for Electric Railways; Merle J. Wightman, of Scranton, Pa., Assignor to the Wightman Electric Manufacturing Company, of same place. Application filed Aug. 12, 1890. An electric railway trolley having a trolley arm provided with a practically universal joint, and a spring tension device tending to move the arm into a vertical position, whereby the direction of pressure between the trolley and the trolley wire is always in a plane practically parallel to the wires.

448,173. Trolley for Electric Railways; Merle J. Wightman, of Scranton, Pa., Assignor to the Wightman Electric Manufacturing Company, of same place. Application filed Aug. 12, 1890. An electric railway trolley arm having a practically universal joint, and provided with a gear to prevent twisting of the trolley arm.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.